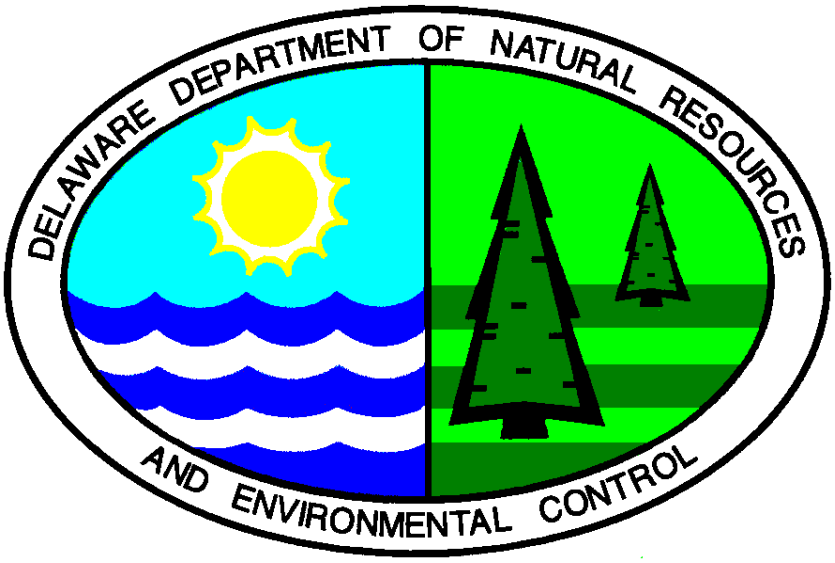
DEPARTMENT OF NATURAL RESOURCES
AND ENVIRONMENTAL CONTROL
DIVISION OF AIR AND WASTE MANAGEMENT
Site Investigation & Restoration Branch



Hazardous Substance Cleanup Act
Guidance Manual

October 1994

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1.1 Regulatory Background

The Delaware Hazardous Substance Cleanup Act (HSCA), 7 Del. C. Ch 91, was enacted by the General Assembly of the State of Delaware in July of 1990. The purpose of the Act is to require prompt containment and removal of hazardous substances and to eliminate or minimize the risk to public health, welfare and the environment from the release of hazardous substances. The Act provides for a fund to be used to clean up facilities where viable responsible parties cannot be identified. For facilities where responsible parties are identified, the Act provides authority to the Department of Natural Resources and Environmental Control (the Department) to enforce cleanup at the responsible parties' expense.

HSCA provides that the Secretary of the Department implement regulations to carry out the provisions of the Act. The Secretary developed and adopted the final regulations in April 1994 under Secretary's Order Number 94-SF-0013. These regulations establish the administrative procedures and standards to identify, investigate, and clean up facilities where a release of hazardous substances has occurred or is imminent. Public and privately owned facilities are subject to this program. The intent of these regulations is to provide a workable process to accomplish effective and expeditious cleanups of contaminated facilities, thus protecting public health, welfare, and the environment.

1.2 Steps in the HSCA Cleanup Process

Figure 1-1 presents a flow chart of the HSCA cleanup process, which is described briefly below. Facilities subject to HSCA regulations would generally go through these steps in the order listed. However, because of site specific conditions, deviations in the number of steps implemented and their order may occur at specific sites.

Facility Identification: Facilities subject to the regulations are identified through the reporting requirements for release of hazardous substances in accordance with Section 3 of the HSCA regulations or through reporting by other federal, state, or local regulatory agencies or the public.
Initial Investigation: An initial investigation of a facility may be conducted by the Department to determine if a suspected release has occurred or if there is an imminent threat of release that warrants further action.

Facility Evaluation (FE): A facility evaluation may be conducted by the Department or the facility owner or operator, to confirm the suspected release or imminent threat of release of hazardous substances at a subject facility.

DELAWARE HAZARDOUS SUBSTANCE CLEANUP ACT
FLOWCHART OF THE CLEANUP PROCESS

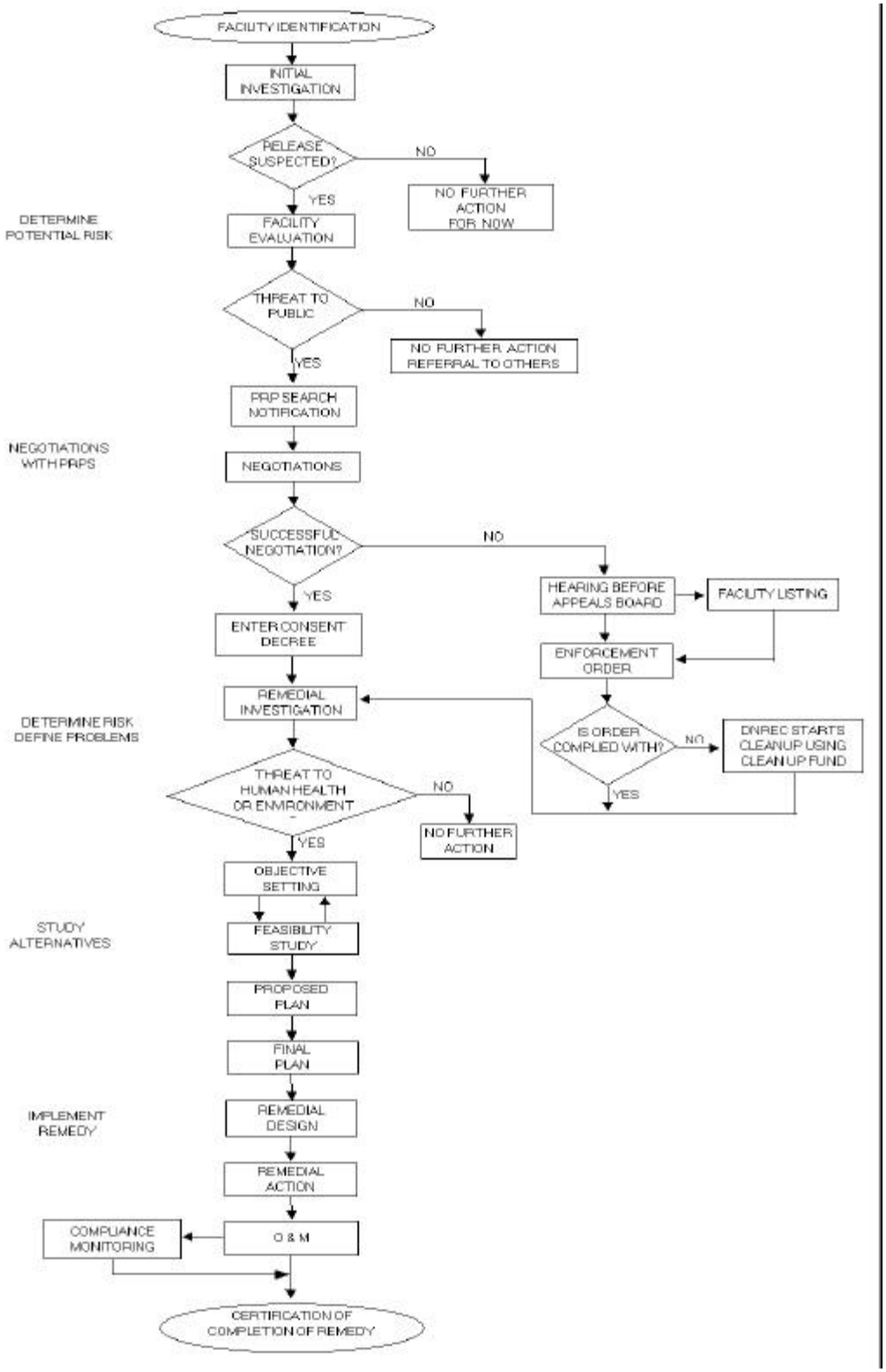


Figure 1-1
HSCA Cleanup Process

The facility evaluation also serves to collect information necessary to evaluate risk to public health, welfare and the environment. If the owner or operator chooses to conduct the FE, a written agreement between that party and the Department must be entered into prior to the initiation of the FE.

Identification and Notification of Potentially Responsible Parties (PRPs): The Department initiates actions to identify and notify the PRPs when a release or imminent threat of release has been confirmed.

Priority List: A priority list of facilities where further response action is required is prepared and periodically updated by the Department. The ranking is based on the hazard ranking of the facility as determined from information collected during the facility evaluation.

Negotiations with PRPs: The Department may invite the PRPs to perform necessary response actions or to conduct investigations at the site by initiating negotiations towards the preparation of a consent decree. If an agreement is not reached, the Department may issue an administrative order.

Remedial Investigation (RI): A RI is conducted at a facility to determine the extent of contamination and the risks to public health, welfare and the environment. The RI typically includes site characterization, field investigations, and performance of a risk assessment as well as collection of engineering data that may be required to complete a feasibility study and/or remedial design.

Remedial Action Objective Setting: Remedial action objectives are both qualitative and quantitative and are developed iteratively throughout the remedial investigation, risk assessment and feasibility study. The objectives predict the expected condition and contaminant levels at the facility following remediation. Input from stakeholders is considered when setting remedial action objectives.

Feasibility Study (FS): Based on the results of the RI and remedial action objectives, a feasibility study of remedial alternatives is conducted. A feasibility study identifies appropriate remedial technologies which will achieve the remedial objectives, groups these technologies into remedial alternatives that would address all the contamination problems at a site and evaluates the alternatives to determine the most effective alternative.

Proposed Plan of Remedial Action: A Proposed Plan of Remedial Action outlining the remedial action selected during the feasibility study is prepared. The Department provides public notice and a comment period. After review and consideration of the comments received, the Department issues a final plan of remedial action, which is incorporated in a remedial decision record.

Remedial Decision Record: The Remedial Decision Record embodies the proposed and final remedial action plans and public comments received by the Secretary.

Remedial Design: Remedial design is the process of preparing the engineering documents that detail the remedial action to be performed. The level of detail of the design may vary from facility to facility, depending on the complexity of the Proposed Plan of Remedial Action. The design may include an engineering design report as well as construction plans and specifications developed in conformance with accepted engineering practices.

Remedial Action: After the remedy selected in the Final Plan of Remedial Action has been designed and specified, its implementation becomes the Remedial Action. The Remedial Action should follow the approved design and achieve all performance measures.

Operation and Maintenance and Compliance Monitoring: Operation and Maintenance (O&M) includes all the activities required to ensure effective operation of the remedy under both standard operating conditions and emergencies. Compliance monitoring is often combined with O&M activities and involves routine testing to determine if the cleanup levels of the contaminated medium have been achieved or if the treated effluent or emission meets discharge requirements.

Interim Response Activity: If the Department determines that an interim measure is necessary to prevent, minimize or mitigate harm to public health, welfare and the environment, it may require interim response activities be conducted prior to the implementation of a final remedial action. These activities may occur at any time during the cleanup process as described above.

1.3 Objective of Guidance Document

The purpose of this document is to provide informational guidance to potentially responsible parties implementing site cleanup under HSCA. It is intended to supplement regular communication with the Department and to standardize the remediation process among facilities. The document is designed to provide ideas and options to PRPs complying with the regulations. It is not intended to replace the regulations; however, if the document and the regulations conflict, the regulations take precedence.

This guidance document should be used by the PRPs and their consultants and contractors in implementing the scope of work or the work plan included in the consent decree. This guidance document is not intended to substitute for professional judgment and knowledge of conditions at the facility. The Department is committed to a high standard of environmental response, in a way that is flexible and appropriate to the problem at hand. Within the regulations and guidance, persons performing the investigation are free to use equipment, techniques, and methods with which they are most comfortable. These must be proposed in the work plan and approved by the Department prior to implementation. Nothing contained in this guidance relieves any signatory to a consent decree from the responsibility for obtaining all necessary approvals prior to field work or for carrying out the terms of the decree.

The Department encourages meetings during the progress of work and requires approval of certain submittals prior to accepting the results of any investigation. Points for formal dialog between the

PRPs and the Department are highlighted throughout this guidance manual. The Department encourages and is receptive to other informal dialog between the parties throughout the process.

This guidance document is organized according to the sequence of steps in the HSCA cleanup process. Chapter 2 describes the determination of potential risk at a facility, and includes the facility identification, initial investigation and facility evaluation. The PRP identification process is described in Chapter 3. The quantification of risk, including the remedial investigation and risk assessment, is presented in Chapter 4. Identification of the appropriate remedial action for the site, through development of remedial action objectives, completion of the feasibility study and preparation of the proposed plan and final plan of remedial action, is described in Chapter 5. Chapter 6 presents the various elements of implementing the site remedy; the consent decree, remedial design, remedial action, operation and maintenance and the certification of completion of remedy.

This chapter discusses phases of the cleanup process that the Department typically performs. Facility or site owners will not generally initiate cleanup activities until the remedial investigation commences under an executed consent decree or administrative order. However, PRPs may conduct the Facility Evaluation under an agreement with the Department. The three steps the Department uses to determine if potential risk to public health, welfare and the environment exists are presented below.

2.1 Facility Identification

The Department identifies facilities from which a release of hazardous substances has occurred or is imminent in a number of ways. The HSCA regulations contain reporting requirements for owners, operators or persons controlling activities at facilities to report incidents involving releases of hazardous substances. Such releases may also be identified during environmental audits conducted at a facility or during the environmental assessment of a property prior to transfer or sale. Additionally, other state or federal agencies may inform the Department when they become aware of a release. Releases may also be reported by the public.

2.2 Initial Investigation

When the Department receives information indicating that a suspected release has occurred or is imminent, an initial investigation is typically conducted to determine if further action is warranted. The initial investigation is conducted by the Department or its contractor. This investigation usually includes a site visit and an evaluation of reports, audits and other records. At a number of facilities, preliminary assessments may have already been conducted under the federal Superfund Program. They are considered to be equivalent to the initial investigation under HSCA. Based on the results of the initial investigation, the Department may decide to conduct a facility evaluation, require an immediate response action or decide that no further action is warranted at the present time. Finding that no further action is warranted does not preclude the Department from further action at a later date.

2.3 Facility Evaluation

If the initial investigation indicates a release or imminent threat of release, the Department conducts a facility evaluation to assess the related risk. The evaluation may consist of a review of general facility and existing information and/or a field investigation, including sampling of soil, air, groundwater, surface water, sediments, and biota as appropriate. The scope of the evaluation is flexible and is dependent on the specific conditions of the facility. At a minimum, enough data to support a preliminary risk assessment must be collected. The site inspection conducted under the federal Superfund Program may be substituted for or used in conjunction with a facility evaluation. The evaluation will generally be conducted by the Department or its contractor. At its discretion, the Department may allow PRPs who enter into a facility evaluation agreement with the Department to conduct the facility evaluation with Departmental oversight. The results of the facility evaluation determine the next step within the process.

HSCA provides for the cleanup of contaminated sites through the identification of potentially responsible parties (PRPs). PRPs are persons or entities which are identified as being responsible for the release or imminent release of hazardous substances from a facility such that the public health, welfare or environment is threatened. Under HSCA, identified PRPs are responsible for the cleanup of the site. The mechanism for initiating this process is either a consent decree which is agreed to by the Department and the PRP or, if the PRP and Department cannot negotiate an agreement, an administrative order.

3.1 PRP Search

Following the facility evaluation at sites where further action is warranted, the Department initiates identification of PRPs associated with the facility. If potential liability is demonstrated, the Department may notify the PRP with a notice letter by certified mail. The notice letter includes the following information:

- Name of the PRP;
- Location of the facility;
- Basis for identifying the PRP;
- Basis for determining the occurrence or imminent threat of a release from the facility; and
- List of other PRPs who have received notice letters.

3.2 Priority List

Facilities which are identified as requiring further response action after completion of a facility evaluation are placed on a priority list. Placement of a facility on the list does not imply that all persons associated with the facility are liable under the regulations or HSCA. The Delaware Hazard Ranking Model is then used to assign a hazard ranking to each facility on the list. The ranking is based on the results of the facility evaluation and other available information. Even if a site is not included on the list, the Department may still conduct or require a response at that site.

The priority list may be updated once every year. Prior to establishing or updating the list, the Department will provide a 30 day public notice and comment period. All comments will be considered by the Department prior to revising the priority list. Reasonable efforts will then be made by the Department to notify any PRP to be added to the priority list. If notification does not occur, however, the Department is not precluded from listing the site or taking action against any PRPs.

If the remedy conducted at the site removes the threat to public health, welfare and the environment, the facility may be deleted from the priority list. This process is subject to the same notification and public comment procedures described above for inclusion on the priority list.

Currently the Department's policy is not to place a site on the priority list if the PRPs have voluntarily entered into a consent decree and are performing the response action.

3.3 Consent Decree

If the Department determines that a response action is warranted at a facility, it will initiate negotiations toward a consent decree. The consent decree contains either a scope of work or work plan that describes the remedial investigation and feasibility study activities to be conducted at the site. The Department and PRPs negotiate the specifics of the work to be completed such that a work plan is prepared and finalized. The initial negotiation period is 90 days with a possible extension of 60 days at the Department's discretion. If an agreement cannot be reached, the Department may, following a hearing, issue an administrative order to compel the PRPs to perform the tasks outlined in the scope of work or work plan.

3.4 Voluntary Cleanup

When a release of hazardous substances is identified through an environmental assessment, the owners or potential buyers may not want to wait for the Department to conduct an investigation. Owners may choose to accelerate the remedial process by conducting their own investigations and, if necessary, remediation with Departmental oversight. The voluntary cleanup process is encouraged by the Department and follows the intent of HSCA. This guidance manual can be used by owners in executing voluntary cleanup, but does not replace the regulations or formal policy of the Department. The voluntary cleanup process must follow the current HSCA regulations. Parties interested in voluntary cleanup may obtain a copy of the Department's policy in this regard.

If completion of the facility evaluation indicates that a risk to public health, welfare or the environment exists, then further action is warranted. In order to determine the appropriate remedial response to this risk, it is first necessary to quantify the risk. This is accomplished by performing a remedial investigation and risk assessment for this site. Because of the technical nature of this work, it is usually necessary for PRPs to contract an environmental consultant to conduct the studies necessary to quantify risk. The potential approaches, and requirements of each of these components of the cleanup process are described in this chapter.

4.1 Consultant Selection

The first step in the planning process for cleanup under the HSCA process is to determine whether an environmental consultant will be needed. Some PRPs have environmental professionals or lawyers on staff that are familiar with the requirements of site investigation and remediation. Unless the environmental department has sufficient staff resources and experience in the cleanup process, however, use of internal professionals may not be the most cost effective approach to completion of HSCA site cleanup and may result in delays in meeting the Department's schedule for response. Additionally, use of an outside firm introduces an element of objectivity into the process which may be important in providing the PRP with an understanding of all available options and the implications of these options on site cleanup.

Because of the specialized services required for many of the elements of the remedial investigation, risk assessment and feasibility study, most PRPs choose to hire an outside consulting firm that is large enough to either provide the technical disciplines needed, or to have working relationships with subcontractors who provide these services. Often it becomes necessary to retain another consultant to perform remedial work. The discussion in this chapter concerns selection of a consultant to perform study-related services for the remedial investigation, risk assessment and feasibility study.

4.1.1 Selection Process

The selection of an environmental consultant should be based on the firm's qualifications to perform the work and cost. In order to make the selection, the PRP must have a clear understanding of the work to be performed and site-specific issues which are critical to the optimum outcome of the remedial process. The following selection process provides an example of how the PRP might select an appropriate environmental consulting firm for completion of the remedial studies. The specific selection process will necessarily be tailored to the conditions of each site, the availability of qualified consultants and the PRP's internal selection procedures.

1. Identify interested firms - The PRP should identify interested firms and solicit a statement of qualifications and a list of the proposed project team members. Firms may be identified through advertisements in newspapers or trade journals, references from other PRPs or past experience with consultants. The Department maintains a list of consultants who have expressed interest in working for the Department. This list is available without endorsement.

2. Short list qualified firms - The interested firms should be screened based on their qualifications as listed in the side bar on the next page. The PRP may want to select only some of these criteria for use at this stage of the process and use other criteria during later stages in the selection process. The firm's proposed project team may be interviewed at this stage in order to narrow down the list of firms. Of the qualified firms, at least three should then be identified for further evaluation. The Department reserves the right to approve or disapprove a consultant, in accordance with the Department's policy on *Minimum Qualification Requirements for Consultants/Contractors Performing Work Under the Delaware Hazardous Substance Cleanup Act*.

3. Solicit technical proposals - Next, the short listed firms should be asked to submit a technical proposal, including costs, for completion of the project. The scope of work provided to the firms should be detailed enough so that accurate and consistent proposals are received from each firm. Because the scope of the project will be dependent on the work plan developed by the consultant and ultimately approved by the Department, it may not be possible for the consultant to initially provide accurate costs for the entire project. The consultant should be able to submit a firm price for preparation of a work plan, and develop costs for the project based on its experience and technical assumptions. The proposed type of contract should be specified so that the consultants may present their expected costs accordingly.

4. Rank consulting firms - The short listed firms should be ranked according to their qualifications and technical proposals. The PRP may want to conduct interviews of the firms at this point, or at least discuss key elements of the proposals with the appropriate personnel. If any of the qualification criteria were not considered in short listing the firms, they should be evaluated for this ranking.

5. Contract negotiation - The PRP should enter into contract negotiations with the highest ranked firm. A specific scope of work should be agreed on and costs submitted by the consultant. Contract issues, including liability, responsibilities and compensation should also be considered and agreed upon. If the PRP and consultant cannot negotiate a contract successfully, the second ranked firm should be requested to enter into negotiations. This process should continue until a contract is agreed upon with a consulting firm.

The PRP may have prior experience with a consulting firm and feel comfortable using that firm to complete the remedial studies. If so, it will not be necessary for the PRP to conduct a formal selection process as described. Consideration of the firm's qualifications against those described below may be adequate to ensure that the appropriate consulting firm is retained.

4.1.2 Qualifications Evaluation

The most critical factor in an environmental consultant's qualifications is technical competence in remedial investigations, risk assessment and feasibility studies. Competence should be demonstrated

by the consulting firm as well as by the proposed project team. It is recommended that the proposed project team be described in the statement of qualifications or proposal and that some assurance of its involvement in the project be made by the consultant. The technical competence of the project team and firm may be best evaluated based on its remedial experience at similar sites. This experience may include work performed under other regulatory programs or under HSCA. Ideally, the consultant should be able to demonstrate a variety of experience under each of these scenarios.

It is important to check client references to gain an understanding of the success of the consultant in completing previous projects. Information may be gained from proposals and qualifications' statements or interviews with the project team. Discussions with client references may also provide information about the nontechnical aspects of the consultant's performance (such as cost control and workload), which may be just as critical to a successful cleanup.

Choosing a Consultant

- Number of similar projects completed and under what regulatory jurisdiction;
- Qualifications of the proposed project team (i.e., OSHA certified, professionally registered);
- Responsiveness of project management to client issues and concerns;
- Ability to identify novel approaches which meet the regulatory requirements and client's needs;
- Quality of example project reports including organization, clarity and technical content;
- Successful experience working with other PRPs, law firms and regulators;
- Firm's reputation and financial standing;
- Size of firm and number of personnel available;
- Current and projected workload;
- Qualifications and past experience with proposed subcontractors;
- Internal cost and schedule control programs; and
- Geographic location of proposed project team.

4.2 Remedial Investigation

The remedial investigation (RI) goal is to more accurately define the conditions at the facility and the risk associated with it.

The objectives of the RI are to:

- Characterize the facility and its actual or potential hazard to public health, welfare, and the environment;
- Identify sources of contamination;
- Evaluate the nature and extent of air, soil, surface water, sediment, and groundwater contamination at the facility and, if applicable, in adjacent areas impacted by activities at the facility;

- Identify all existing and potential migration pathways for hazardous substances, pollutants or contaminants caused by on-site activities, including direction, rate of migration, and dispersion of contaminants;
- Provide sufficient data to complete a risk assessment; and
- Provide sufficient data to fully evaluate all potential remedies, as necessary.

HSCA regulations provide for a phased approach to investigating environmental problems. The results of earlier phases may focus and define the scope of study in subsequent phases. To achieve the objectives of the RI efficiently, the Department encourages maximizing the use of existing data and phasing of the investigation. Results of facility evaluations completed by the Department are available and should provide a starting point for the RI.

The Consent Decree is an agreement between the Department and the PRPs whereby the PRPs commit to finance and perform the remedial investigation. The components of a consent decree are listed in table 6-1.

Performance of the RI involves a number of individual tasks. Planning documents are required by the Department that detail the performance of these tasks. Work may begin once the Department has approved the planning documents.

4.2.1 Work Plan

During the Consent Decree negotiation process, a remedial investigation work plan is prepared. The work plan should clearly present an understanding of the environmental conditions at the facility, incorporating available background information. The work plan should identify gaps in the existing information and develop data collection objectives that fill those gaps. Where possible, the work plan should identify tasks that may be contingent on the results of field work. This alerts the Department to decisions in which it will need to be involved. PRPs are encouraged to schedule meetings with Department personnel at appropriate times during the development of the work plan and supporting documents (discussed on the next page) to solicit additional guidance. It is anticipated that this cooperative approach will facilitate completion of the remediation process, thus saving time, money, and addressing concerns about public health, welfare, and the environment.

Supporting documents which should be addressed initially in the work plan and then more fully developed and modified as necessary include the following:

- Sampling and analysis plan (SAP), which contains the field sampling plan and the quality assurance project plan;
- Health and safety plan;
- Waste management plan;
- Community relations/public participation plan; and
- Project organization plan.

The purpose and general content of each of these plans is described in this section. All of the above elements may be combined in one comprehensive document.

4.2.1.1 Sampling and Analysis Plan

The Sampling and Analysis Plan (SAP) describes the collection of data and the procedures that will be used to ensure its quality. The SAP is comprised of two elements, (the field sampling plan (FSP) and the quality assurance project plan (QAPP) that may be prepared as separate plans at the discretion of the PRP. However, depending on the complexity of the RI, PRPs are encouraged to streamline the project planning process by combining these elements. An example of a model sampling and analysis plan is provided as Appendix A.

The FSP element of a SAP contains information relative to site background, sampling objectives, sampling location and frequency, sample designation, sampling equipment and procedures, and sample handling and analysis. The FSP should note tasks or procedures that may change depending on field conditions. (Any deviation from the FSP should be noted in the RI report.) The FSP should also be detailed enough that a field team unfamiliar with the facility would be able to use it to gather the samples and field information requested. Specific information about sampling techniques and requirements are provided in Section 4.2.3.

The QAPP element of a SAP presents the policies, objectives, and functional activities undertaken to assure the quality of data collected for the RI. All field sampling and data collection should be conducted within the context of an overall strategy for assessing the facility. HSCA regulations provide for a phased approach to investigating environmental contamination, where the results of initial field reconnaissance screening may focus and define the scope of study in subsequent phases. In accordance with this approach, the QAPP must specify the sampling and analytical procedures associated with field reconnaissance screening in addition to those required for data to be used in the risk assessment and evaluation of remedial alternatives.

Additional information on preparation of the SAP may be obtained from the following:

Soil Sampling Quality Assurance Users Guide, EPA, March 1989
Standard Operating Procedure for Chemical Analytical Programs, State of Delaware DNREC
Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, EPA, October 1988

4.2.1.2 Health and Safety Plan

The health and safety plan (HASP) should describe all measures, including contingency plans and facility access restrictions, that will be implemented during field activities to (1) ensure protection of public health and welfare; (2) protect the health and safety of personnel involved in the RI/FS; and (3) provide site security. Preparation of the HASP should include an evaluation of both existing site conditions and the proposed field activities so that potentially hazardous activities and appropriate safety precautions may be identified. The HASP should be prepared or reviewed by a certified industrial hygienist (CIH), certified hazardous materials manager (CHMM), certified safety professional (CSP), or other qualified person.

At a minimum, the HASP must incorporate and be consistent with the requirements of:

- OSHA Safety and Health Standard 29 CFR Part 1910.120, Hazardous Waste Operations and Emergency Response;
- OSHA standards 29 CFR Part 1910 (General Industry Standards) and 1926 (Construction Industry Standards);
- Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, DHHS (NIOSH) Publication Number 85-115, October 1985.
- Standard Operating Safety Guidelines, USEPA, Office of Emergency and Remedial Response.

This will require, at a minimum, inclusion of the following elements:

- Description of the site, environmental features, history of waste operations, waste types and characteristics;
- A hazard evaluation of existing site conditions and of each site task and operation;
- A description of personal protective equipment (PPE) to be used by employees for each of the site tasks and operations to be conducted; provisions for altering levels of PPE.
- A description of the frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used;
- Decontamination procedures;
- The name of the site health and safety officer and the names of key personnel and their responsibilities; phone numbers for the health and safety officer and emergency support services;
- Employee training requirements;
- Medical surveillance requirements;
- Site control measures and standard operating procedures for the site;
- A contingency plan to address anticipated emergencies;
- Entry procedures for confined spaces that meet 29 CFR 1910.146 and 29 CFR 1910. 147, if applicable.

4.2.1.3 Waste Management Plan

The work plan should anticipate the production of wastes and include a plan to deal with them. The contents of the waste management plan may be in a separate section or included with discussions of the media to be sampled. In general, wastes should not be assumed non-hazardous and must be treated accordingly. Waste produced by the remedial investigation may include:

- Cuttings from soil borings or monitoring wells;
- Drilling fluid, well development and purge water;
- Decontamination fluids; and
- Used personal protection equipment and other domestic trash.

The principles upon which an acceptable waste management plan should be based are:

- Minimize the quantity of waste generated;
- Leave waste on site provided it does not worsen the conditions at the facility;
- Remove wastes that pose an imminent hazard; and
- Comply with the Resource Conservation and Recovery Act (RCRA).

While this brief guidance cannot be substituted for the body of regulations on hazardous waste, a few specific suggestions may be offered:

1) In general, the PRP may elect to dispose of any waste as hazardous waste with no more analysis than the hazardous waste facility requires. All federal and state reporting and permitting requirements must be met.

2) Drill cuttings may sometimes be replaced in the bore hole. If the soil surface is not known to be contaminated and the drill cuttings are suspected to be, then the top 12 inches of the hole should be filled with clean fill. If the hole penetrates a confining layer, then it should be plugged with bentonite at least two feet into the top of the confining layer. Wells should be double cased when the potential for cross-contamination of aquifers exists. Specific regulations administered by the Department's Water Supply Branch govern piercing confined aquifers. Any drill cuttings which will not fit back into the hole should be drummed for off-site disposal. However, in the case of a secure facility that has surface contamination, they may be left on the surface.

3) In the case of a landfill or other facility with widespread contamination and access control, decontamination water, development water and drilling fluid may be disposed of in an infiltration basin on the fill area. For wells not on the facility property, however, contaminated development water cannot be disposed of outside the facility boundaries without testing. Such development water must be drummed or tanked. If security is adequate, drums may be stored at the facility until analytical results are available. Proposed storage areas should be an explicit part of the waste management plan.

4) Disposable personal protection equipment should be removed from the site and disposed of in an appropriate manner.

4.2.1.4 Community Relations Plan

Community participation is an integral part of the State Superfund Program. Each facility poses different threats to public health, welfare and the environment; therefore, the community relations/public participation requirements will vary from facility to facility. While development and implementation of the community relations plan is primarily the responsibility of the Department, the PRP may be required to develop and implement portions of the community relations plan under the Department's supervision. The plan should document the previous public relations activities for the site and those issues that are of concern to the community. The level of detail will be dictated by the complexity of issues at the site. Contents may include the following:

1) Applicable public notice requirements:

- Date of public meetings/hearings;
- Length of comment period; and
- Potentially affected vicinity and other involved areas.

2) Information repositories.

3) Methods for identifying the public's concerns including:

- Interviews;
- Questionnaires;
- Contact with community groups or other organizations; and
- Establishment of citizen advisory groups.

4) Methods for addressing the public's concerns including:

- Public hearings;
- Educational workshops;
- Press releases;
- Newsletters;
- Fact sheets;
- Maps; and
- Written and oral communication.

5) Coordination of public participation requirements.

6) Revisions to the plan.

7) Any other elements that the Department determines to be appropriate for inclusion.

Additional information on preparing a public participation plan is available in Community Relations in Superfund: A Handbook (USEPA, Interim, June 1988).

4.2.1.5 Project Organization Plan

The project organization plan should describe how the project will be managed by the PRP and its contractors, subcontractors, and consultants. It should include an organizational chart with the names and titles of key personnel and the lines of communication between them and the Department.

A description of each individual's responsibilities, qualifications and relevant experience should be included.

4.2.2 Site Physical Characterization

Evaluation of the site and its physical characteristics is required to gain an understanding of the potential for contaminant migration and identification of potential receptor populations. This information should be collected prior to performing the field investigation portion of the RI, so that specific data needs may be addressed during field sampling and analysis. Information about the site and its physical characteristics will also be needed to develop and screen remedial action alternatives during the feasibility study.

4.2.2.1 Operational History

Information to be Collected

- Facility boundaries
- Building names and functions
- Entrance locations, fences
- Site topography and drainage
- Chemical storage areas
- Process areas
- Waste handling areas (ponds, piles, buildings, treatment systems)
- Location of prior spills
- Location of water wells or injection wells
- Past operations - processes, discharges, production volume

The operational history of the facility reveals basic information about the sources of contamination at the site. Past waste handling practices and hazardous chemical incidents, such as spills, are of particular interest. Sources include interviews with past and present owners/operators, regulatory records and enforcement history (including the initial investigation and facility evaluation), aerial photographs, operational records, and past topographic surveys. The sidebar lists some of the information to be collected in an investigation of the history and physical setting of the facility. Most of this information should be available as existing data.

4.2.2.2 Geology

An understanding of regional and site geology is necessary for efficient completion of all subsequent phases of the cleanup process. For hazardous wastes released to soils, geologic characteristics affect or control the migration of contaminants through the surface to the subsurface and ultimately to groundwater. This information then has a direct impact on the evaluation of the extent of contamination and on the potential receptors that may be at risk from exposure. Additionally, geological characteristics influence site investigation procedures and evaluation and implementation of site remediation.

Information on both bedrock and unconsolidated geology should be obtained during this phase of the RI. A summary of the types of information needed is provided in the sidebar. Regional information may be obtained from published reports, state geologic maps, USGS quadrangle maps and previous site investigation reports. The Delaware Geological Survey provides a comprehensive listing of reports with regional information. They may be contacted at (302) 831-2833.

Knowledge of regional geology aids in confirmation of site geology and in identifying which aspect of site geology may have the most influence on the various phases of the cleanup process. Site geological information may be obtained from previous site investigation reports, if available. Site reconnaissance mapping, including field mapping, analysis of aerial photography and surface geophysics, may provide information about site surficial geology. Information about site subsurface geology may require completion of test borings. Borehole geophysics may also be useful.

Geologic Data Needs

- Unconsolidated Sediments and Overburden
- Stratigraphy
- Mineralogy
- Structure (faults, bedding, unconformities)
- Depositional environment(s)
- Particle size, sorting, porosity and permeability

Consolidated Sediments

- Type of rock (igneous, metamorphic, sedimentary)
- Stratigraphy
- Petrology/mineralogy
- Structure (folds, faults, joints, karst, foliation, fractures)
- Depositional environment(s)
- Particle size, sorting, porosity and permeability

In addition to regional and site geology, information on surface soils and the vadose zone should be collected. Properties of these units directly affect the movement and availability of contaminants to the subsurface and groundwater. Some typical characteristics which should be evaluated are listed in the sidebar on the next page. Sources for this information include existing literature and direct field or laboratory testing of samples.

Soil Data Needs

- Soil Characteristics
  Types, holding capacity, temperature, biological activity, engineering properties
- Soil Chemistry Characteristics
  Solubility, ion specification, absorption coefficients, leachability, cation exchange capacity, mineral partition coefficients, chemical and sorptive properties
- Vadose Zone Characteristics
  Permeability, variability, porosity, moisture content, chemical characteristics, extent of contamination

4.2.2.3 Hydrogeology

For exposure pathways which are based on use or contact with groundwater, hydrogeology is a critical factor in the data collection process. Characterization of the site hydrogeology includes consideration of site geology, hydraulic properties of the groundwater zones and groundwater quality.

A summary of specific data requirements is provided in the sidebar to the right. Much of this information is related to geology and may be obtained through the same sources listed previously. Regional and site specific information on groundwater quality may be obtained from local water supply companies and regulatory agency reports.

Hydrogeologic Data Needs

Geologic Aspects
- Type of water-bearing unit or aquifer
- Elevation, thickness and extent of unit
- Type of porosity
- Presence of impermeable units or confining layers
- Elevation, thickness, extent of water table

Hydraulic Aspects
- Hydraulic properties
- Pressure conditions
- Groundwater flow directions, volume and rate
- Recharge and discharge areas
- Surface water interactions
- Seasonal variations

Groundwater Quality
- pH, conductivity, temperature, total dissolved solids, salinity, specific contaminant concentrations and dissolved oxygen

4.2.2.4 Surface Water Hydrology

Collection of surface water hydrologic data is necessary for characterizing site contamination, assessing risk to public health, welfare and the environment and for evaluating and implementing remedial technologies. Surface water features include natural and manmade streams, lakes, ponds and wetlands, as well as ditches and trenches that convey stormwater runoff. These features may receive discharges directly or indirectly, through hazardous substances discharged to soil, groundwater or air. Contaminants that reach surface water may be transported by flow as a suspended solid, adsorb to sediment particles or be transported as a dissolved material. Each of these possibilities need to be evaluated during the remedial investigation. Collection of the data presented in the sidebar to the right is necessary to make this evaluation. Sources for this information include topographic maps, site inspection and public agency maps, records, reports and surveys.

Surface Water Data Needs

- Drainage Patterns
  Overland flow, topography, channel flow pattern, tributary relationships, soil erosion and sediment transport and deposition
- Surface Water Bodies
  Flow, stream widths and depths, channel elevations, flooding tendencies, physical dimensions of impoundments, structures, and surface and ground water relationships
- Surface Water Quality
  pH, temperature, total suspended solids, suspended sediments, salinity and specific contaminant concentrations
- Wetlands
  Type, quality, values, functions and location

Meteorological Data Needs

Local Climate
- Precipitation
- Temperature
- Wind speed and direction
- Presence of inversion layers

Weather Extremes
- Storms
- Floods
- Winds

Release Characteristics
- Direction and speed of plume movement
- Rate, amount, temperature of release
- Relative densities

4.2.2.5 Meteorology

Meteorological conditions influence the migration of contaminants which have been discharged to soil, groundwater, surface water and air. Knowledge of these conditions and their impact on site contamination are critical in the development of exposure pathways during the risk assessment. This information influences the performance of the field investigation and remedial action because meteorological conditions impact site worker exposure. Data needs related to local climate, weather extremes and release characteristics are summarized in the sidebar to the left. Sources for this information include national and local weather services, federal and state emergency planning offices and site and regional air monitoring data.

4.2.2.6 Human Populations and Land Use

Once the potential migration pathways for site contaminants have been identified, the factors which place human populations in contact with them must be determined. An evaluation of the risk that site contamination poses under current and future uses of the site, as well as during field investigations and remedial action may be conducted. All potentially exposed populations should be identified and characterized with respect to size, location and sensitive subpopulations. This information is available through census and survey data. Land use data is used to characterize the contact between populations and contaminants. This information is summarized in the sidebar to the right. Potential sources include USGS topographic maps, land use plans, zoning maps and local planning agencies.

Ecological Data Needs

- Potentially affected ecosystems
- Endangered species
- Sensitive environments such as wetlands, flood plains, wildlife breeding and refuge areas
- Specially designated areas, including wild and scenic rivers or parks
- Observable biocontamination
- Recreational uses of area, including hunting, fishing and other potential pathways for human exposure

Receptor Identification

Location and use of surface water

- Drinking water intakes and distribution
- Recreational areas such as swimming and fishing
- Connection between surface water bodies

Local use of groundwater as a drinking water source

- Number of wells
- Distance of wells from site
- Expected direction of groundwater flow
- Depth of wells
- Availability of alternate sources

Human use or access to the facility and adjacent areas

- Residential
- Commercial
- Recreational

Location of population with respect to the facility.

- Proximity
- Prevailing wind direction

4.2.2.7 Ecology

Evaluation of the risk to environmental populations requires an identification of the potentially exposed populations and characterization of the contamination to which they may be exposed. Plant and animal populations and unique ecological systems associated with the site should be identified. These include not only those populations or systems located on-site, but those off-site which are impacted as well. Of particular importance is the identification of biological populations which serve as an exposure pathway for human populations such as fish or animals consumed by humans. Data needs are summarized in the sidebar to the left. Sources include site surveys, public agency surveys, maps and reports, and reports prepared for adjacent properties.

4.2.3 Contaminant Characterization

Following the evaluation of the factors that influence contaminant migration, the remedial investigation should focus on defining the vertical and lateral extent of contamination. In this stage of the cleanup process, the sampling and analysis plan approved by the Department is implemented. This section of the guidance document describes some of the general sampling issues that may be considered during the development and implementation of the sampling and analysis plan and provides information regarding sampling specific media.

4.2.3.1 General Sampling Considerations

General sampling considerations may be applicable to more than one media of concern. The general requirements for sampling and analysis are described in the State of Delaware's *Standard Operating Procedures for Chemical Analytical Programs* (SOPCAP) and must be detailed in the approved sampling and analysis plan. Requirements include the following:

- Sampling objectives;
- Sample location and frequency;
- Recording of field notes and activities;
- Sample designation; and
- Sample handling and analysis.

In addition to these requirements, the determination of background concentrations, use of field screening techniques, selection of monitoring parameters and preparation for field activities are issues that should be considered by PRPs and are described below.

Determination of Background Concentrations: Samples collected and analyzed during the RI may exhibit a range of constituents and concentrations. In order to determine if these results are indicative of site contamination, the concentration of each constituent that represents the pre-existing site condition or "background" concentration must be obtained. Some parameters which are commonly detected at contaminated sites are naturally occurring and their presence does not necessarily mean that the site is contaminated. Metals are naturally present in soils; their concentrations dependent on the mineral content of the rock from which they originated. Organic contaminants are not naturally occurring but may have been present prior to the site operations that are being investigated. This anthropomorphic pre-existing contamination is often found in industrial areas, where past use of the site or adjacent properties may have impacted site media. In order to accurately quantify the risks associated with site contamination, the concentrations naturally and/or anthropomorphically present must be determined so that they may be factored into the evaluation of RI data.

The location of background samples must be based on careful evaluation of site operations and physical characteristics. At least one background location must be established for each medium evaluated during the RI. Background locations should be selected to most closely represent the characteristics of each medium prior to site operation impacts. A careful review of site operations records must be completed to identify areas of the site which were not used for activities which are the alleged sources of contamination. Soil background samples must be collected at the same depths

and from the same soil types as those suspected of being contaminated. Water background samples should be collected at locations upstream or upgradient of the site, and should resemble site samples as much as possible. All parameters which are to be analyzed during the RI should also be analyzed for in background samples.

Field Screening: Field screening at HSCA sites entails sampling and analysis using methods that employ less rigorous QA/QC requirements than required in typical federal or state contract laboratory program (CLP) approved protocols. The objective of field screening is to refine and determine subsequent sampling and analysis requirements for use in the preparation of the RI. The Department suggests that field screening be utilized to minimize costs and streamline the data collection process. Field screening may be used to:

- Confirm the presence or absence of contaminants;
- Provide a streamlined and logical approach to the collection of data; and
- Reduce the cost for sampling and chemical analysis.

The procedures and analytical methods to be utilized in field screening must be specified in the SAP. Accuracy, precision and method detection limit information are determined by the data quality objectives in accordance with the SOPCAP.

The process of field screening is iterative. It should be designed to strategically select samples at each level of data quality, with the goal of obtaining a higher degree of certainty from the overall data set without sacrificing either the quantity of samples analyzed or the quality of data collected. Generally, three levels of screening data are recognized in site investigations. These are described on Table 4-1.

Selection of Analytical Parameters: The proper selection of analytical parameters is critical to the efficient characterization of site contamination. Ideally, only those parameters that have resulted from facility history and are present in concentrations which would create a risk will be analyzed. Because of the heterogeneity of wastes and the impacts that media conditions may have on them, it is often difficult to select the appropriate analytical parameters.

In order to determine which parameters should be analyzed, three issues should be considered. The nature of the substances, with respect to their constituents and chemical/physical reaction products, is the first consideration. The effects of the media on the substance should then be considered. These may include impacts to contaminant or breakdown product mobility, stability and persistence. Finally, the concentrations of the constituents present in background samples should be evaluated.

TABLE 4-1
HSCA CLEANUP PROCESS
REMEDIAL INVESTIGATION
LEVELS OF SCREENING DATA

Levels Of Screening Data	Description
Level I On-Site Field Screening:	Utilizes portable instruments to provide real time data to assist in the optimization of sampling point locations and for health and safety support. Data quality criteria include instrument calibration and operational issues.
Level II On-Site Field Analysis:	Utilizes portable analytical instruments on-site, or in mobile laboratories stationed near a site. Field analysis can provide information about air, soil and water contamination. Hazardous substances can be identified through organic and inorganic analyses at this level. Depending upon the types of contaminants, sample matrix and personnel skills, both qualitative and quantitative data may be obtained. The data quality for field analyses is dependent upon the QA/QC steps taken in the process (e.g., documentation of blank injections, calibration standard runs, runs of qualitative standards between samples, etc.). The amount and type of documentation available will vary with the type of analysis and the standard operating procedures used. For example, the documentation available for a field gas chromatograph would consist of a log book and the output of an integrator or strip chart recorder for all samples, standards, and blanks analyzed.
Level III Laboratory Analysis:	While not occurring in the field, this level of screening provides laboratory analysis using standard EPA, ASTM or other recognized procedures other than current contract laboratory program routine analytical services for organic and inorganic compounds. Level III provides data for site characterizations, environmental monitoring, confirmation of field data and to support engineering studies (e.g. design, modeling, and pilot/bench studies). In specific cases, Level III analyses may also provide data for risk assessment requirements. Level III protocols all have built-in QA/QC, including calibration runs, surrogate standards, etc. External QA, which is included in the SOPCAP, is employed in the form of trip blanks, field blanks, equipment blanks, and duplicate samples submitted with the samples.

Indicator parameters may be utilized to efficiently assess the range and extent of contamination. For example, total dissolved solids (TDS) could be analyzed in groundwater around a landfill or one or two easily analyzed metals could be selected at a plating site, rather than the whole list of possible metals. Because indicator parameters may not always detect critical contaminant constituents, their use should be approved by the Department during development of the sampling and analysis plan.

Preparation: Some of the tasks required as part of implementing the sampling and analysis plan should be completed before the start of the field activities in order to minimize schedule delays. The following activities should be initiated as soon as possible after approval of the sampling and analysis plan by the Department:

- Obtain permission and coordinate schedule for access to site and adjacent areas to be sampled;
- Coordinate and contract subcontractor services;
- Identify and obtain all equipment and supplies;
- Coordinate on-site and remote laboratory services in accordance with the QAPP; and
- Determine requirements for on-site workspace, utilities, and storage.

4.2.3.2 Field Investigation Procedures

Soil: The intent of soil sampling is to characterize and define the spatial limits of soil contamination. Soil sampling should be conducted in areas of known and suspected disposal and in areas where groundwater or surface water contamination exists and no known or suspected source has been identified. The sample collection methods that are used for soil sampling will depend on the depth of the soil sample being collected, the need for lithologic information, the condition of the soil and the amount of sample needed for analysis. Soil samples are typically classified as surface and subsurface. Additionally, the vapor present in the pore space of soils where volatile constituents are expected to be present may be sampled and requires special sampling procedures.

Surface Soil Sampling: Surface soil samples are typically collected from areas where spills or leaks are suspected and provide a quantitative indication of the existence of contamination. Samples collected for this purpose generally are limited to the top two to six inches below ground surface, although samples up to 1 foot in depth can be considered surface samples. Because of the limitations on depth, surficial sampling will not provide information about the vertical extent of contamination. They may be used to indicate the horizontal extent of contamination, and are generally required to evaluate hazards from ingestion, inhalation or dermal exposure during the risk assessment.

Surface samples may be collected through the use of trowels, spatulas or scoops, augers, triers, soil punches and ring samplers. Trowels, spatulas and scoops consist of scooped blades with attached handles and may be used when required sample volumes are 1 pint or less. If larger sample volumes are needed, shovels may be used to collect the sample. The advantage that these tools offer is that a number of samples may be collected within a short period of time. Triers are 1 to 2 inch diameter tubes which are cut lengthwise to form a trough. The edge of the triers is ground to form a sharp tip and the trier is equipped with a handle for insertion. They are driven into the soil

at an angle, twisted to cut a core and removed to collect the sample. Soil punches are thin-walled steel tubes which are driven into the ground with a mallet, twisted and removed. The soil is then pushed or shaken from the tube. In rocky or loose, granular soils, soil punches are not effective because the soil will not remain in the punch. Ring samplers are steel rings which are driven into the ground and removed to provide a surface sample. This tool is not effective in loose, sandy soils or stiff clays.

Subsurface Soil Sampling: Subsurface soil sampling may be used to indicate the vertical extent of soil contamination and to provide information on the types of subsurface soils present. The effect of soil type on contaminant migration may then be inferred. Subsurface samples may be collected using hand operated or power operated equipment, and may range in depth from one foot below ground surface to depths of 40 feet or more. Typically, hand operated equipment is capable of collecting samples to a depth of six feet below ground surface.

Hand operated subsurface sampling equipment includes soil probes, core samplers, hand augers and bucket augers. Soil probes are usually stainless steel or brass tubes fitted with a T-handle and are pushed into the soil in 5-to 10-inch increments. At the desired depth of sampling, the tube is removed and the soil extruded. Core samplers operate in a manner similar to triers, but use extension rods to sample depths greater than 1 foot below ground surface. Hand augers are constructed of a spiral cutting blade attached to a metal central shaft. The hand auger is screwed into the soil to the depth desired and removed so that the soil sample may be taken from the threads. These samples are typically disturbed samples and cannot be used to determine soil lithology. The depths at which samples are collected from should be considered to be approximate. Bucket augers are operated in the same manner as hand augers, but consist of a two cutting blades attached to a core (bucket). The bucket attaches to a metal central shaft which is turned using a T-handle. This sampling method may be used in soil types such as dense, stony, single grain or saturated materials, where hand auguring is not practical.

Power operated equipment is necessary when the depth to be sampled exceeds five to ten feet, depending on the soil conditions. Samples may be collected from boreholes or trenches. Boreholes are created and advanced to the depth required using methods such as wash boring, auger boring and rotary drilling. Samples are then collected at specific depths or continuously using split spoons or thin wall tubes. In order to obtain the most accurate lithologic information from subsurface sampling, continuous sampling is recommended. Thin wall tubes are used to produce high quality undisturbed samples from cohesive soils. The samples must generally be extruded in the laboratory, however. Split spoon samples also allow the collection of undisturbed soil samples. They are easily viewed in the field for lithologic evaluation, and are easily available for field screening and sampling. Because the split spoon samplers are advanced using a weighted hammer and drill rod, recording the number of
hammer blows required to advance the sampler provides an indication of soil density. For a detailed evaluation of subsurface soil conditions, trenches or test pits may be used. These are excavated by using a backhoe and are usually limited in depth by the sloughing of the excavation and safety considerations. Soil samples may be collected at desired depths or soil types using surficial sampling tools such as trowels and triers.

Soil Vapor Sampling: Soil vapor sampling has proven to be effective in delineating volatile soil and groundwater contamination and migration of contamination. This procedure consists of extraction and analysis of vapors released from volatile organic compounds that accumulate in the pores of unsaturated soils. The concentration of these vapors in the unsaturated zone can give a gross indication of contamination in the soil or groundwater. Soil vapor sampling is relatively quick and inexpensive. However, it provides limited information because it is an indirect method of measurement. Vapors emitted from contaminated soil may migrate through the soil and be detected through soil vapor sampling at different vertical and horizontal locations than the contamination. As a result, additional sampling is usually required to verify soil vapor sampling results.

The equipment and procedures employed in soil vapor sampling vary. The procedure generally consists of driving a stainless steel tube into the sample area, inserting teflon tubing and drawing a vapor sample with an appropriate instrument. In some instances, the vapor samples are collected in an air sample bag or with a syringe. The collected sample is then injected into a portable gas chromatograph and analyzed.

Groundwater: The RI should be designed to evaluate the nature and extent of groundwater contamination. This evaluation is necessary to identify present and potential impacts to public health, welfare and the environment from contaminated groundwater. In order to assess the potential for groundwater contamination at the site in a cost-effective manner, the use of existing data, conceptual modeling and investigative phasing is recommended. Suggestions for developing this approach are provided in this section.

Investigation Approach: Regional geologic and hydrologic conditions are usually available in existing data bases and should have been assessed during the previous task of site characterization. In order to determine site specific conditions and assess potential groundwater contamination, it is usually necessary to supplement regional information with detailed facility-specific information. Detailed information is obtained through on- and off-site subsurface investigations (e.g., installation and sampling of monitoring and/or observation wells). Wells may be used to collect data that describes the nature and extent of contamination, the direction of groundwater flow, and to identify affected aquifer(s). Well information also identifies gaps in the facility specific data base and guides further investigations.

Because of the costs involved with implementing a groundwater investigation, the siting and the number of monitoring wells to be installed should be given careful consideration. It is recommended that the PRP first develop a conceptual model of the groundwater system, potential contamination and its migration. The model should consider the magnitude of the release, characteristics of the released wastes, potential migration pathways, exposure routes and relevant hydrogeologic data. Depth to groundwater, well yield and water quality information should be obtained from domestic, commercial or industrial wells within the area. All of this information should have been gathered during the site characterization task. Once a conceptual model is developed, the number of wells, their locations and depths, and the parameters to be monitored may be determined accordingly. Depending on the complexity of the groundwater system, the

type of contamination, and the existing knowledge base at the site, a phased groundwater investigation may be implemented.

The initial phase of a groundwater investigation should be designed to determine if groundwater contamination is present. A limited number of monitoring wells should be sited and screened at depths that will allow interception of contaminant plumes, as well as identification of background conditions. The use of indicator parameters based on facility operations and history should be considered. If contamination is detected during this phase of monitoring, then an expanded monitoring system should be designed and implemented.

Often at this initial stage, drive point sampling is conducted using small diameter sampling tools such as a hydropunch. This method of sampling allows for rapid collection of groundwater samples without the expense and time requirements of installing permanent wells and generating soil cuttings.

For shallow water tables in nongravelly soils the drive point samples can be pushed to the sampling depth manually or with conventional drill rods. For deeper sampling, a small diameter borehole is first installed to within four feet of the desired sampling depth and the drive point sampler is then lowered through the auger flights or borehole with drill rods and advanced to the sampling depth using a cat-head. The sampler chamber is allowed to fill and then is withdrawn from the borehole and the sample transferred to appropriate sampling containers. The augers and rods are withdrawn from the borehole and the hole is backfilled with grout.

An expanded monitoring system should supplement the data obtained from the initial groundwater monitoring system and/or drive point sampling. To be cost-effective, the initial wells should serve as components of the expanded system to the maximum extent possible. The vertical extent of contamination detected should be determined through the use of well clusters or multi-depth wells. Wells should be sited arealy both within the plume and at its fringes in order to provide quantification of the minimum and maximum concentrations of contaminants present. The identification of all contaminants present in the groundwater is necessary during this phase. Use of expanded laboratory analyses such as RCRA Appendix IX may be necessary in order to accomplish this. The rate of contaminant migration should also be assessed through the collection of hydrologic data. Aquifer testing such as slug tests, pump tests or tracer studies may be required to provide this information. If the investigation does not yield sufficient data to project contaminant transport, the Department may require a groundwater modeling study.

Monitoring Well Installation Procedures: Monitoring well installation requires the completion of a borehole using one of the drilling techniques described for subsurface sampling and the construction of a well within the borehole. Soil samples are typically collected during the completion of the borehole to provide geologic data, as well as soil contaminant data. If soil sampling is not required, other drilling techniques such as hydraulic rotary drilling may be used. Generally, wells should be drilled by the hollow stem auger method unless alternate methods are necessary and approved by the Department.

Construction of all monitoring wells must adhere to Delaware's "Regulations Governing the Construction of Water Wells" as implemented by the Department's Water Supply Branch and a permit must be obtained prior to any well installation. The specifications for materials and equipment, as well as the drilling and development techniques, must be presented in the sampling and analysis plan for the RI and approved by the Department prior to implementation. After construction and equilibration, wells should be developed to produce turbidity free water at a rate of at least 1 gallon per minute.

Monitoring Well Sampling: General sampling procedures for monitoring wells include pre-sampling activities, well evacuation, sample withdrawal, field testing and sample preparation for analysis. In addition, samples to be analyzed for organic or metal and some conventional parameters may require specialized procedures.

Prior to sampling groundwater monitoring wells, a number of tasks should be completed. These include the general media sampling considerations such as records, equipment decontamination, sample labeling and tracking and sample handling mentioned at the beginning of this section. For groundwater monitoring, the following additional activities should also be considered:

1. Wells should be checked for indications of damage or tampering (e.g. missing caps and/or locks, casing defects, etc.).

2. If organic constituents are expected to be present, the well cap should be removed and a field instrument used to measure volatile organic vapors within the well and in the ambient air above the well. Any positive readings should be compared to the HASP requirements for safe working conditions and appropriate action taken.

3. The depth to water and total depth of the well should be measured and recorded.

Well evacuation is completed to ensure that the water present in the well is removed and new water, representative of the aquifer formation, is allowed to enter prior to sampling. A well volume is calculated using measurements made during the pre-sampling tasks. A minimum of three well volumes should then be removed from the well. The indicator parameters, pH, conductivity and temperature are measured. If these field measurements are consistent within 10 percent, adequate well evacuation may be assumed. Otherwise, additional volumes must be purged from the well until the field readings stabilize or Department approval for alternate requirements is solicited. Typically, discussions in the field between the consultant and Department lead to a solution. In any event, all deviations to the presented work plan should be noted in field logbooks. The most commonly used methods for well evacuation and their advantages and disadvantages are shown in Table 4-2.

After completion of the well evacuation, the well should be sampled. However, the water level should be checked first to make sure the well has recovered. There are a number of choices available for sampling equipment. Factors to be considered in the selection of sampling equipment include:

- The construction material of the equipment and its potential to leach or adsorb contaminants;
- The ability to dedicate equipment to wells or thoroughly clean equipment between sampling in order to avoid cross contamination;
- Minimizing exposure of the sample to atmospheric conditions; and
- The equipment requirements for well evacuation and whether they coincide with analytical objectives.

Both manually operated and power operated equipment are available. The most frequently used types of sampling equipment include bailers, suction lift pumps and submersible pumps. The advantages and disadvantages of these types of samplers are presented in Table 4-2.

When obtaining samples for inorganic analyses, it is common to analyze both a filtered and nonfiltered sample to determine if observed contamination is due to desorption from particulates versus dissolved constituents. Background samples should be analyzed similarly.

Surface Water: Surface water contamination may result from direct discharges of hazardous waste or indirect discharges of contaminants such as leachate from contaminated sources or contaminated groundwater. The objectives of a surface water investigation may include the following:

- Identification of the nature, rate and extent of the release;
- Determination of the fate of contaminants once released to surface waters; and
- Evaluation of the temporal effects that may impact contaminant fate.

In order to meet these objectives, a series of samples of surface water must be collected over time. These would include background samples, samples from the suspected point or area of release and samples from the impacted receiving water body. Depending on the nature of the release and the heterogeneity of the surface water body, the locations and depths where each of these types of samples are collected may need to change over time. This approach requires that the contaminant plume and surface water characteristics be monitored and the locations and depths of sampling adjusted as necessary to provide adequate characterization of contaminant presence and migration.

The frequency of surface water sampling is also dependent on characteristics of the release and surface water conditions. When the source is known and relatively constant, and surface water conditions are homogeneous, infrequent sampling may be sufficient. Sometimes contaminant migration is dependent on periodic events such as rainfall. In these situations, event monitoring may be recommended. A third alternative for surface water sampling frequency is continuous sampling. Typically, this is only appropriate for use with indicator parameters that are measurable with an instrument probe such as pH or dissolved oxygen.

Table 4-2

Advantages and Disadvantages of Monitoring Well Evacuation and Sampling Equipment

Type	Advantages	Disadvantages
Bailer	Available in a variety of diameters and materials	Sampling is a time consuming process
	No external power source needed	Transfer of sample to bottles may result in aeration and loss of volatiles
	Portable, easy to clean, readily available and inexpensive	
Suction Lift Pump (Centrifugal, Peristaltic)	Relatively portable	May not work in deeper wells
	Readily available and inexpensive	Construction material may not be compatible with some contaminants
		Sampling may cause loss of some volatiles and dissolved gases
Submersible Pumps	Variety of diameters and materials available	Sediment laden water may damage some pumps
	Fairly portable	Relatively expensive
	Large pumping rates possible	
	Volatile loss minimized during pumping	
	Readily available	

Both filtered and unfiltered groundwater samples should be analyzed for the expected contaminants and breakdown products, as well as conventional water quality parameters. Conventional parameters may include temperature, dissolved oxygen, dissolved and suspended solids, oxygen demand, conductivity and pH. If a relationship between these general parameters and contaminant concentrations is established, it may be possible to use these parameters as indicators to reduce analytical testing requirements. This should be proposed in the sampling and analysis plan and approved by the Department prior to implementation. Conventional parameters are also necessary for design considerations.

Monitoring results should be expressed in terms of concentration and loading. This requires quantification of the flow corresponding to sample collection. Flow measurement is also necessary to develop contaminant transport information and to monitor the selection of sampling locations and depths. Flow measurements also aid in subsequent feasibility study and design tasks should the surface water body require remediation. There are a number of flow measurement techniques, that measure velocity, depth, hydraulic pressure or volume over time. The selection of the appropriate technique for each site is dependent on the type of surface water body being monitored.

Sediment: Unless contaminated soil is discharged directly into a surface water body creating sediment, sediment contamination results from the precipitation or adsorption of surface water contaminants to naturally occurring sediment. Sediments typically accumulate wherever the velocity of flow is reduced in the surface water body below the velocity necessary to maintain soil particles in suspension. Once present, contaminated sediments may also serve as a source of surface water contamination due to leaching of contaminants into the water column. Because of this interrelationship between sediment and surface water contamination, sediment sampling locations, frequency and parameters usually correspond to the sampling program for surface water.

Sediment samples may be collected as disturbed or undisturbed samples. Disturbed samples are collected using a clamshell type scoop device. There are a number of specific sampler names and variations, but all function by scraping the surface of the sediment to remove the sediment sample. Relatively undisturbed samples may be collected using a coring device. When vertical profiling is important, this approach is preferred. A disadvantage, however, is that small sample volumes are collected. For either approach, the selection of sampling devices should be consistent with the sampling objectives. For example, metal samplers should not be used for trace metal analysis and plastic materials should not be used for organics analysis.

Air: Volatilization of organics and emissions of airborne particulates directly from hazardous substances, or indirectly from contaminated soil, surface water, sediment and groundwater, may require development and implementation of an air monitoring program. The air pathway should be considered whenever a residential population is located near the facility or when site conditions are such that airborne emissions are frequent and/or continuous, e.g. dry, sandy soil in an area of high wind velocity.

The objective of the program should be to characterize the air emissions of hazardous substance constituents at the facility boundary for risk assessment purposes and at the potential points of exposure to workers. Instantaneous air sampling to establish ambient conditions and identify

compounds for more detailed analysis may be conducted using field instruments. These instruments may include combustible gas analyzers, oxygen meters, respirable dust monitors, organic vapor analyzers, photoionization detectors and calorimetric indicators. Continuous air monitoring is conducted using stationary sampling devices over longer periods of time. Air samples are collected in sorbent tubes or on particulate filters and analyzed in the laboratory for specific contaminant concentrations. Results are expressed with respect to the time over which they were collected. Consideration of the meteorological conditions identified during the site characterization is critical in selecting monitoring locations and frequency. Meteorological monitoring should be conducted concurrently with air monitoring or sampling to allow consideration of potential atmospheric impacts on air emissions. Once site characteristics and air monitoring or sampling data are available, air modeling may be used to project the expected emissions on an annual basis or during remedial activities.

Biota: Chemical, ecological, and toxicological data must be integrated to determine if a relationship between site contaminants and ecological effects exists. Chemical analyses of water, soil, or other appropriate media are necessary to establish the presence, concentrations, and extent of specific contaminants. Ecological studies are necessary to establish adverse ecological effects. More detailed information concerning ecological studies is described in Section 4.3.5.1

There are three major categories of investigative methods utilized during ecologic studies: field surveys, toxicity tests and biomarkers. Each provides a different type of information and therefore all three may have to be applied to evaluation of the site.

Field surveys involve measurement of the structural and functional characteristics of biological populations and communities at the site. Comparison should be made between the facility and a reference site.

Toxicity tests are then used to establish a link between adverse ecological effects and toxicity of wastes. Toxicity tests measure the effects of contaminated media from the site on the survival, growth, and/or reproduction of aquatic and terrestrial biota. Usually samples of soil, sediment and water are collected from the site and tested in the laboratory on standard laboratory test species. Tests can also be run in-situ and with resident species from the site.

Biomarkers are measurements of selected endpoints in individual organisms, typically physiological or biochemical responses, that serve as sensitive indicators of exposure to contaminants and/or sublethal stress. They include measures of bioaccumulation as well as concentrations of enzymes such as cholinesterases, genetic abnormalities, physiological responses, and histopathological or skeletal abnormalities. A major disadvantage is lack of accepted, standardized and tested markers for many of the contaminants of interest at hazardous waste sites.

4.2.3.3 Laboratory Analysis

In addition to approving the sampling and analysis procedures for the field investigation as part of the sampling and analysis plan, the Department must approve the selection of the analytical laboratory to be used for the field investigation. The Department maintains a list of approved

laboratories for analytical work under the HSCA cleanup process and also evaluates laboratories not already approved according to a three step process. The analytical laboratory first submits a statement of qualifications and relevant quality assurance manuals for review and evaluation by the Department. Assuming these are acceptable, the Department submits performance evaluation samples to the laboratory for analysis and reporting. For laboratories providing acceptable results and presentation, the Department or its representative conducts an audit of the facility. Since the process may take considerable time, allowances should be made during project planning to allow the process to be initiated early. Approved laboratories are subject to ongoing audits and performance evaluations during the performance of the field program.

All analytical procedures used to provide data for the risk assessment and evaluation of remedial alternatives must be approved as part of the sampling and analysis plan for the site and must be consistent with the procedures contained in the Department's *"Standard Operating Procedure for Chemical Analytical Programs" (SOPCAP).* Any modifications to these procedures must be approved by the Department prior to their implementation. All communication with the laboratory regarding these changes, as well as routine information exchanges, must be documented in writing. When non-routine issues are discussed or resolved, all impacted parties must receive a copy of the written documentation.

4.2.3.4 Data Evaluation

Field investigations conducted under the HSCA cleanup process may generate large amounts of data. In order to effectively evaluate the quality of the data and its implications for contaminant characterization, it is necessary to approach data evaluation with an overall data management plan in mind. The plan should include data compilation, validation and presentation. Each of these elements is described in this section.

Data Compilation: All of the data from the field investigation must be compiled and organized to facilitate subsequent phases of data evaluation. Analytical data from the laboratory, as well as field data, must be compiled and organized such that information may be easily cross-referenced to determine significance. Analytical data should be tabulated to include the following information:

- Sample identification;
- Sample type;
- Sample location;
- Sample depth;
- Sampling date;
- Laboratory identification number;
- Parameter analyzed for;
- Result of analysis; and
- Detection limit.

When large amounts of data are generated by the laboratory, the receipt of analytical data in an electronic format should be considered. Laboratories produce the paper analytical report from a computer file which may also be submitted to the client on disk. This service is usually available at

a nominal charge and greatly increases the cost effectiveness of data manipulation and review. It also removes a data entry step and the potential for transcription errors, thus improving the overall quality of the data.

The analytical data tabulated for each sample should be cross-referenced to the field data recorded during its collection. Most field data would have been recorded in a field log book. Unless otherwise indicated by the Department, it is usually not necessary to transcribe the log book notes into a table for review. The page number should be identified for each sample, however, and added to the data tables generated as described above. This facilitates reference to field conditions during the data validation and evaluation process.

Data Validation: Once all of the data is tabulated, its quality can be evaluated. Data validation and reduction should follow the requirements of the approved sampling and analysis plan, in accordance with the Department's SOPCAP. Data validation and reduction includes an evaluation of the data's precision, accuracy, completeness and representativeness, in accordance with approved laboratory and field procedures. The results from the quality control samples should be reviewed and the implications to data quality assessed. Any replicate samples should be averaged and the number of samples noted. Data outliers should be identified and any potential causes documented. Additionally, the detection limits reported for each sample should be reviewed against the sampling and analysis plan requirements and an assessment of their appropriateness for data quality made.

The results of the data validation and reduction process should be documented by footnotes in the raw data tables. Any data determined to be suspect due to a data transcription or processing error should be revised and the Department notified. Although plausible explanations for other suspect data points may be proposed, unless the Department approves deletion of suspect data, all data must be used in subsequent manipulation and evaluation.

Data Presentation: Data presentation involves the manipulation of data in tables and graphic displays to assist evaluation and to facilitate decision making. Sorted summary data tables may be created that list only that information from the data compilation tables relevant to the description of a pattern or trend. Typical information expressed in tables might include groundwater monitoring results that exceed background concentrations and frequency of detection data for particular contaminants. Generation of these types of summary data tables is useful by itself to characterize site contamination. It also facilitates the generation of graphic displays for the more detailed evaluation of contamination extent and migration. An example summary table is shown in Table 4-3.

A number of options for the graphic display of data are available. The most commonly used options include bar and line graphs, site maps with data superimposed, isopleth maps, and vertical profiles. Displays may be created by hand or computer software. One important consideration in selecting the presentation approach is whether unknown conditions between points are to be estimated, and if this is appropriate for the particular site. Both analytical and numerical models are available that will infer data between data points, as well as project data for various future conditions. It must be remembered, however, that models are suitable for use as a tool and cannot replace actual site data.

Bar and line graphs are the simplest graphic representation of data and may be used to show the change in concentration per unit variable, such as time or distance from the contaminant source. The dependent variable should be presented along the Y axis and the independent along the X axis. A maximum of 3 to 4 dependent data sets should be presented, in order to maximize the clarity and usefulness of the graph. The range of both axis labels should be selected so that the data points are spread over the entire range. If only a few data points would otherwise be outside the graph range, they could be represented with discontinuous lines or bars. Bar graphs should be used when the data between points may not be comfortably inferred. Examples of these graphs are shown in Figure 4-1.

Generation of area or plan views are useful for depiction of site conditions and sampling locations. The same base map may then also be used to identify contamination extent and migration through the addition of sample concentrations. For areas where the number of uniformly spaced sampling locations is not adequate to infer concentrations between points, discrete data points should be posted and located. Inferences based on site knowledge may then be made about the extent and migration of contaminants. Where adequate data is available, isopleths may be created. Isopleths use lines to represent equal concentrations of contaminants
over the site and may be generated by hand or computer program. If computer generated, the isopleth map must still be evaluated and corrected for site conditions that may impact contaminant migration but which were not part of the data input to the computer program. Example area views are shown in Figures 4-2 and 4-3.

Vertical profiles along a transect provide information about the vertical distribution of contaminants and geologic materials. When the transect contains sampling locations distributed along a relatively straight line, the profile is a two-dimensional cross section. If the locations are not located in a line, a fence diagram showing three-dimensions may be prepared. Three-dimensional graphs may also be prepared using computer programs. An example cross section is shown in Figure 4-4.

Through the data compilation and review activities described previously, information about the physical site characteristics, source of contamination and nature and extent of contamination is obtained. All information is necessary to develop an understanding of the fate and transport of the contaminants and of the impacts to human health, welfare and the environment.

Table 4-3

SUMMARY OF CHEMICALS IN SURFACE SOIL OF THE SUMP OUTFALL AREA

CONCENTRATION (ug/kg)

	Frequency of Detection	Range of Detected Concentrations		Location of Maximum	Range of Non-Detect Concentrations	
		Minimum	Maximum		Minimum	Maximum
CHEMICALS						
VOCs						
Acetone	3/5	37.0 J	660 J	SB46-01	12.0 UJ	13.0 UJ
SVOCs						
Naphthalene	1/5	390 J	390 J	SB47-01	750 UJ	840 UJ
Acenaphthene	1/5	930 J	930 J	SB47-01	750 UJ	840 UJ
Dibenzofuran	1/5	490 J	490 J	SB47-01	750 UJ	840 UJ
Fluorene	1/5	840 J	840 J	SB47-01	750 UJ	840 UJ
Phenanthrene	4/5	340 J	7100 J	SB47-01	840 UJ	840 UJ
Anthracene	2/5	250 J	720 J	SB47-01	750 UJ	840 UJ
Carbazole	1/5	1100 J	1100 J	SB47-01	750 UJ	840 UJ
Fluoranthene	5/5	550 J	8000 J	SB47-01	-	-
Pyrene	5/5	890 J	8600 J	SB47-01	-	-
Benzo(a)anthracene	5/5	270 J	3100 J	SB47-01	-	-
Chrysene	5/5	430 J	3200 J	SB47-01	-	-
Bis(2-ethylhexyl)phthalate	2/5	330 J	600 J	SB49-01	750 UJ	840 UJ
Benzo(b)fluoranthene	5/5	640 J	4700 J	SB47-01	-	-
Benzo(a)pyrene	4/5	830	2300 J	SB47-01	840 U	840 U
Indeno(1,2,3-cd)pyrene	4/5	550 J	1700 J	SB47-01	840 U	840 U
Benzo(g,h,i)perylene	4/5	440 J	1400 J	SB47-01	840 U	840 U
PESTICIDES/PCBs						
Not Analyzed						

Sample Group:
SB45-01, SB46-01, SB47-01, SB48-01, SB49-01.

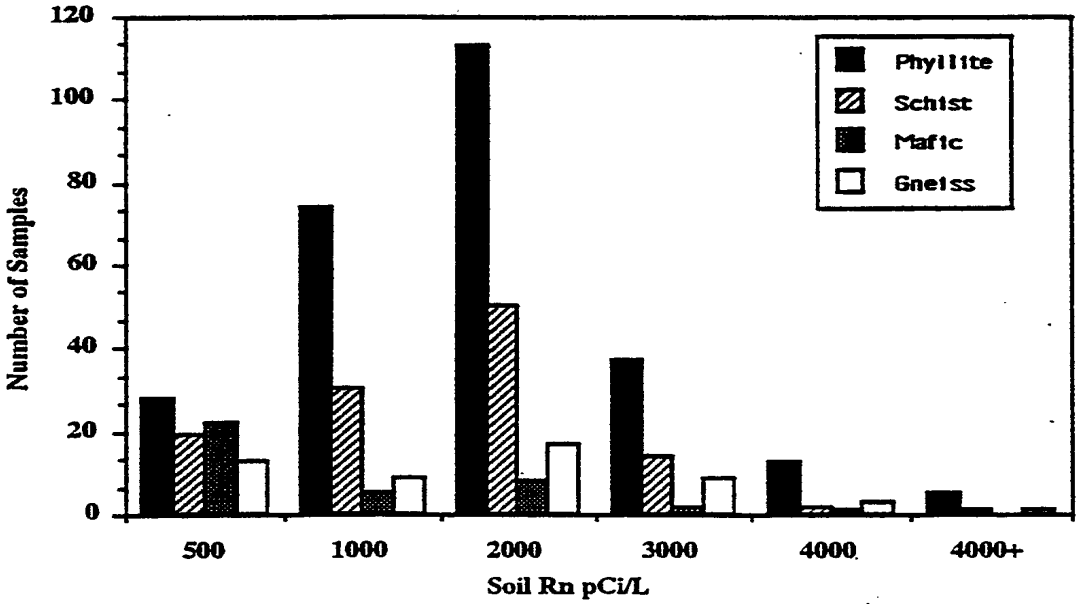
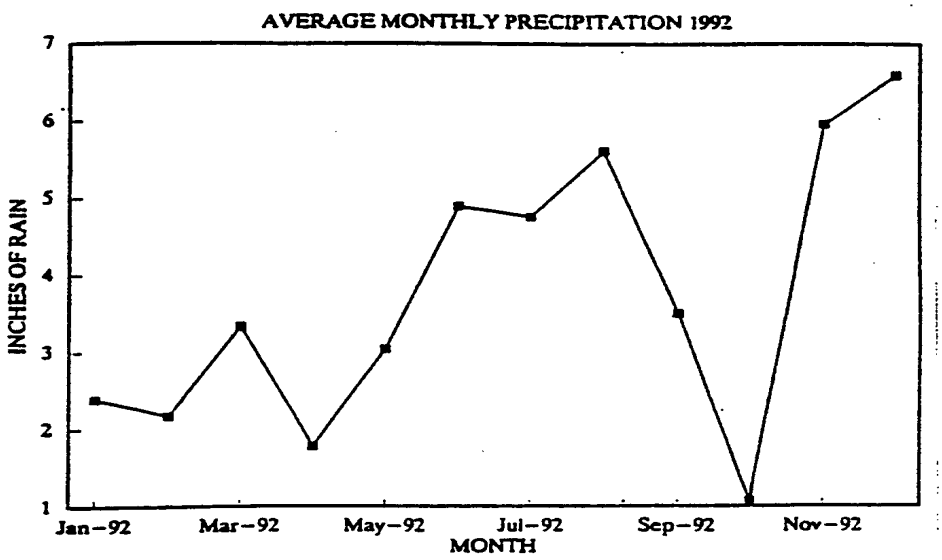


Figure 1A. Soil gas radon for four major rock types in the Piedmont of Maryland.



EXAMPLES OF BAR AND LINE GRAPHS

Figure No. 4-1

4.3 Risk Assessment

4.3.1 Introduction

Risk assessment is the use of environmental and research data to define the probability of human health or ecological effects due to exposure of people or biota to hazardous materials. Both current and possible future exposures should be considered. For most sites a baseline human health risk assessment and a baseline ecological risk assessment are required. Human health risk assessments are generally quantitative, while baseline ecological risk assessments may be qualitative or quantitative.

Since the RI/FS process is aimed at characterizing the nature and extent of risks posed by uncontrolled hazardous waste facilities and for developing and evaluating options to remediate these risks, risk assessment plays an essential role. Three distinct phases of risk evaluations are performed during an RI/FS:

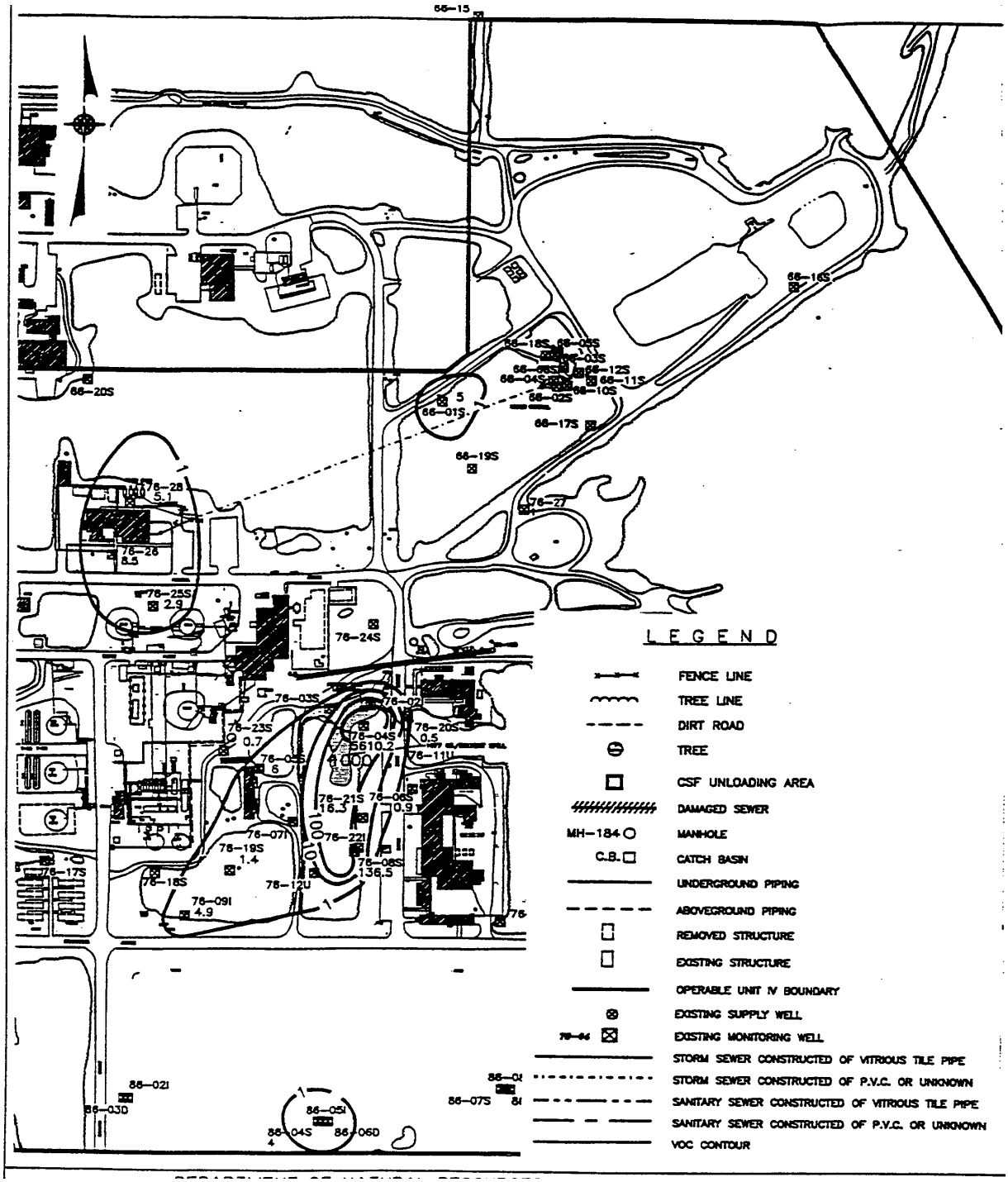
1) Baseline Risk Assessment
2) Development of Remedial Objectives
3) Remedial Alternative Risk Evaluation

The first two evaluations are quantitative. The third, remedial alternative risk evaluation, requires a qualitative assessment of potential risks prevalent during, and remaining after remedial action.

The baseline risk assessment quantifies the current and potential future risks to the public and the environment posed by the concentrations of hazardous substances identified at the facility in the absence of any remedial action. If these risks total greater than the 1 in 100,000 cancer risk level or a level corresponding to a hazard index value of one, the Department may determine that a remedial response is required.

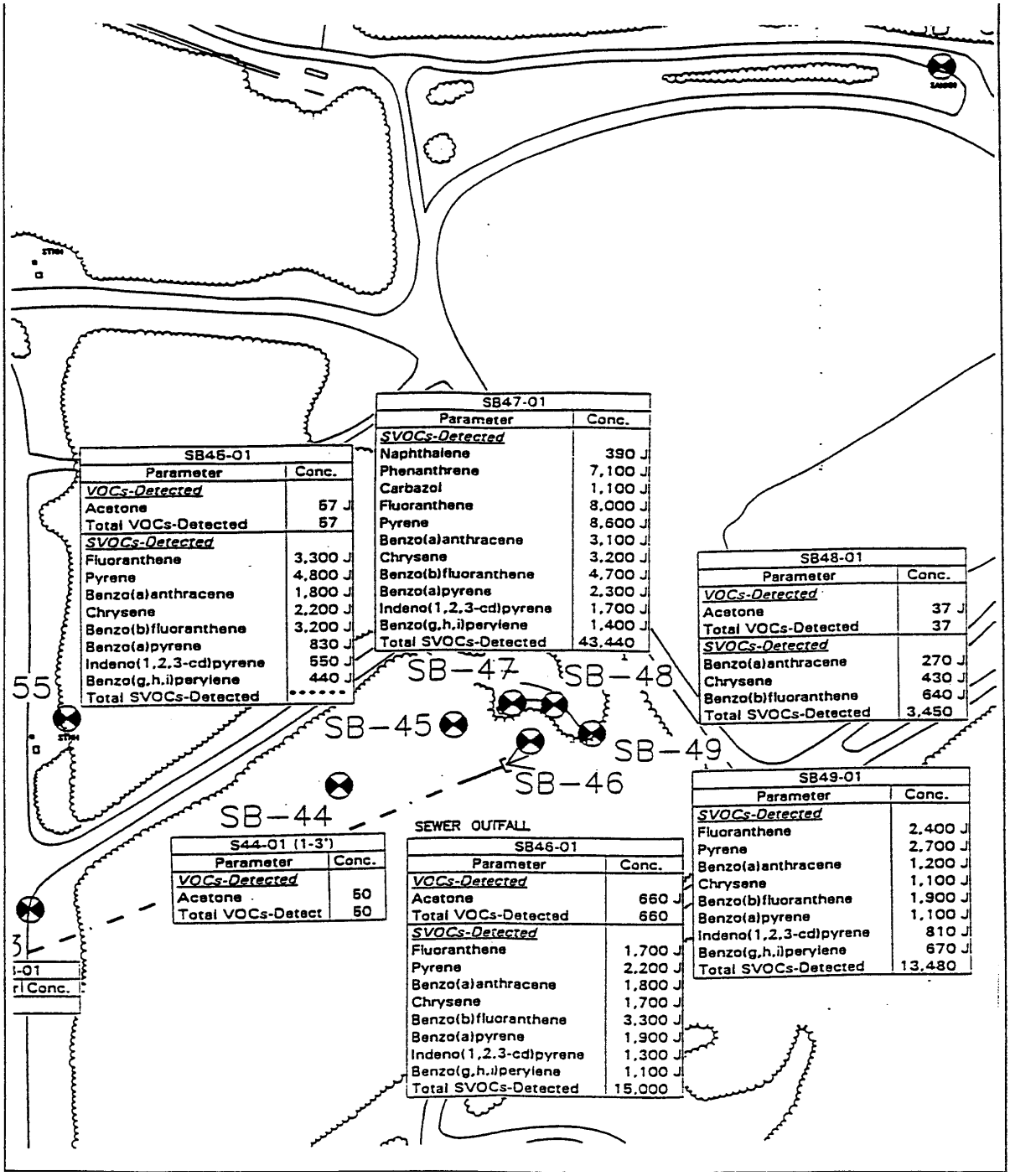
It should be emphasized that the Department is most concerned about <u>current</u> risks that are identified at a facility. When evaluating potential <u>future</u> risks, the Department considers how the facility will most likely be used, rather than all possible future use scenarios.

During the development of remedial objectives, cleanup levels are established for the chemicals at a facility that contribute the most to the overall risk and hazard index calculated in the baseline risk assessment. This quantitative evaluation is essentially the reverse of the calculations performed for the baseline risk assessment, and should follow the requirements of Section 9 of the *Delaware Regulations Governing Hazardous Substance Cleanup* as amended.



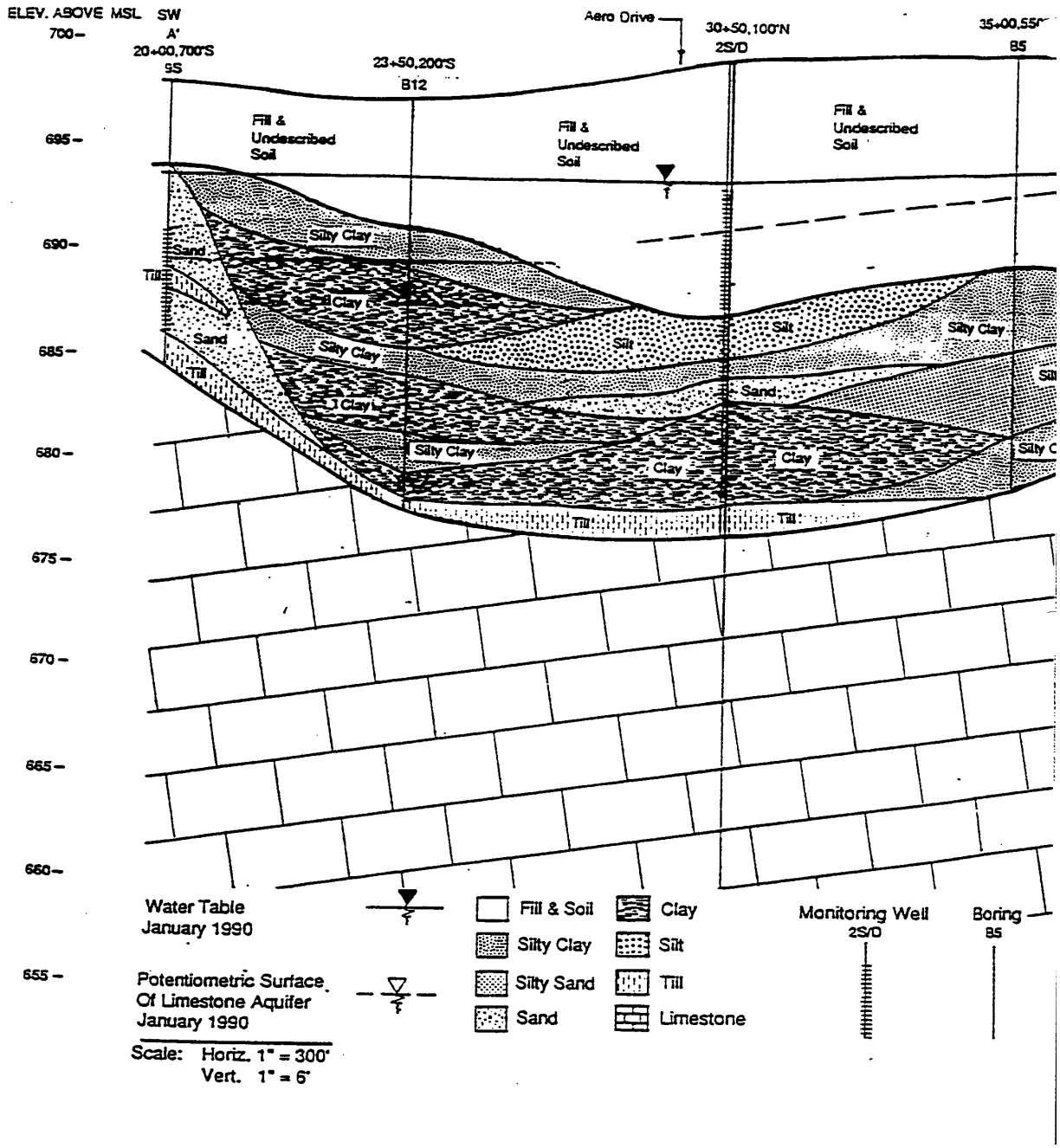
EXAMPLES OF ISO-CONTOUR MAP

Figure No. 4-2



EXAMPLES OF BASE MAP WITH POSTED CONCENTRATIONS

Figure No. 4-3



EXAMPLES OF CROSS-SECTION

Figure No. 4-4

Remedial alternative risk evaluation takes place during the detailed analysis of alternatives in the feasibility study. For this evaluation, the residual risk (long term effectiveness) and risk during the remedy implementation (short term effectiveness) are discussed for each alternative, and then compared between alternatives. While this discussion is generally qualitative, it is sometimes helpful to quantify the risks, especially when an alternative is perceived as being "risky" (e.g. when the site is

in or close to a residential population) and risk becomes an important consideration in selecting the alternative. Further discussion of this evaluation is found in Chapter 5.

4.3.2 Cleanup Standard Option

In lieu of a risk assessment, standards or criteria established by other states or the U.S. Environmental Protection Agency (USEPA) which are based on "de minimis" risk may be used to determine the need for remedial action and to determine appropriate cleanup levels. To implement this option, the concentrations of environmental contaminants obtained during the RI are compared to the appropriate cleanup criteria for the media in question to determine if an unacceptable health risk exists. If the upper 95% confidence interval of the mean concentration for any contaminant exceeds the cleanup criteria, remediation would be required at the facility.

By choosing the cleanup standard option (in place of the conventional risk assessment process) the applicant may expedite the RI/FS process with a subsequent reduction in costs. The cleanup standards or criteria used must be at least as protective as cleanup levels that would be developed under State of Delaware Regulations Governing Hazardous Substance Cleanup (Section 9). The option to use cleanup standards from other states or the USEPA is decided upon by the Department on a site specific basis and may be rejected for specific sites. The Department will provide appropriate guidance regarding the use of cleanup standards in place of a Risk Assessment.

4.3.3 Work Plan Issues

Rigorous scoping of the risk assessment early in the remedial investigation process saves time and money by ensuring a sampling plan that reflects potential exposures and specifies the use of appropriate sampling and analytical methods. Including risk assessment concerns while preparing the remedial investigation work plan ensures that the data from the RI will support the risk assessment and that the risk assessment will assist in determining what type of remedial action is necessary at the site.

The basic data needed to conduct baseline risk assessments include:

- Contaminant concentrations in the key sources and media of interest;
- Characteristics of sources, especially relating to release potential;
- Characteristics of the environmental setting that affect fate, transport, persistence or bio-accumulation of contaminants;

- Identification of human receptors;
- Exposure routes and extent of actual or expected exposure; and
- Toxicity of contaminants in media to which receptors could be exposed.

To this end, the risk assessor should review existing data and conduct a preliminary exposure assessment, identifying type and duration of exposure, potential exposure routes and key exposure points for each medium. This information guides the sampling strategy and required QA/QC requirements. In addition, the likely contaminants and their toxicities at the detection limits should be evaluated to determine if there are any special analytical needs. Also, special attention should be given to obtaining sufficient background samples so that site-related contamination can be distinguished from naturally-occurring or anthropogenic background levels.

4.3.4 Baseline Human Health Risk Assessment

The purpose of a baseline human health risk assessment is to evaluate the actual and potential threat to the public posed by the release of hazardous substances from the site. The baseline health risk assessment is generally composed of four sections; data evaluation, exposure assessment, toxicity assessment and risk characterization.

4.3.4.1 Data Evaluation

For the purposes of performing a baseline risk assessment, there are nine steps that should be followed during data evaluation to organize the data from the RI into a useful form. These nine steps are presented in Table 4-4. The product of data evaluation is a list of the samples that is

Table 4-4

Data Evaluation for Risk Assessment

1	Gather all data available from the site investigation and sort by medium.
2	Evaluate the analytical methods used.
3	Evaluate the quality of data with respect to sample quantitation limits.
4	Evaluate the quantity of data with respect to qualifiers and codes.
5	Evaluate the quality of data with respect to qualifiers and codes.
6	Evaluate tentatively identified compounds.
7	Compare potential site-related contamination with background.
8	Develop a set of data for use in the risk assessment.
9	If appropriate, further limit the number of chemicals to be carried through the risk assessment.

used to estimate exposure point concentrations for all chemicals of potential concern. Concentrations of chemicals at exposure points should be organized by medium.

Data Usage. Data used in the risk assessment should not include chemical detections that were rejected in data validation but should include chemical detections with laboratory or validation qualifiers that indicate estimated concentrations (i.e. "J"). Also excluded are chemical detections that were not significantly higher than the concentrations detected in associated blanks or background samples.

The final list of chemicals of potential concern should be organized by media and should include all chemicals that were positively identified in at least one sample of a medium. In addition, chemicals that were not detected in a given medium but were detected in other media and would be expected to be present in that medium, can be included at one-half the Sample Quantitative Limit (SQL) or at the SQL if information indicates the concentration is closer to SQL than one-half the SQL.

Selection of Chemicals of Concern. In some cases, the list of chemicals of potential concern is very lengthy and retaining all chemicals through a quantitative assessment consumes too many resources and too much time. In some cases the Department may approve reducing the number of chemicals. The selection of chemicals of concern must follow a procedure that identifies the hazardous substances that exhibit the highest potential risk to public, welfare and the environment. Essential nutrients (e.g. sodium or calcium) may be eliminated if the concentrations are low enough that their presence does not cause toxic effects in exposed individuals. Where toxicity values are only available for certain chemicals within a chemical class, data for all chemicals in the class can be grouped and evaluated as one. A concentration/toxicity screen can be used to identify the chemicals contributing the majority share to the total risk, thereby eliminating chemicals that contribute less than a specified fraction (agreed upon by the Department), often 1%.

Data Presentation. The results of data evaluation should be presented in a format that clearly supports the chemicals of concern chosen and facilitates the calculation of exposure point concentrations. Sample summary formats for presenting chemicals in all media sampled (Table A) as well as within specific media (Table B) are shown on Table 4-5. Table B shows how certain chemicals can be included in media even when not detected, if they are present in other site media. Note that Chemical B will be eliminated from the final list of chemicals of concern because it was not found in a significantly higher concentration than background.

4.3.4.2 Exposure Assessment

Exposure assessment is the process of measuring or estimating the intensity, frequency, and duration of human exposures to chemicals currently present in the environment or of estimating hypothetical exposures. The exposure assessment combines the use of environmental data, transport modeling or measurements and standardized assumptions to calculate or estimate possible human exposure. This estimation produces the dose or intake value which is used in the risk calculation.

TABLE 4-5

Data Presentation Formats

Table A - Chemicals Detected on Site

Chemical	Soils	Groundwater	Surface Water	Sediment
A	X	X		X
B	X	X	X	X
C	X			X
D	X			
E		X		
F	X	X	X	
G	X	X		

Table B - Chemicals of Potential Concern in Medium X

Chemical	Frequency of Detection[a]	Frequency Above Background	Range of Sample Quantitation Limits (units)	Range of Detected Concentration (units)	Background Levels
A	3/7	3/7	5-50	320-4600	ND-10
B	7/7	0/7	100-500	480-1200	500-1500
C[b]	0/7	--	10	<10	--

-- = Not available.

[a] Number of samples in which the chemical was positively detected over the number of samples available.

[b] Carried through as chemical of potential concern because detected in other media and likely present in this media below detection limits.

Step 1 Exposure Setting. The first step in an exposure assessment is to characterize the exposure setting and the potentially exposed populations (workers, trespassers and/or residents) on and near the site. Physical characteristics of the environment should be noted including such basic features as climate, vegetation and hydrology. Local populations should be described with respect to characteristics that influence exposure; i.e., location relative to the site, current and future land use, activity patterns, and subpopulations of special concern (children, nursing women, elderly). While current zoning classification may not clearly divulge existing or potential receptors, in some instances it may be used to restrict exposure scenarios that need to be considered in the risk assessment.

Step 2 Exposure Pathways. The next step is to identify the pathways by which the populations may be exposed. Exposure pathways are generally evaluated by identifying all potential release sources at the facility and the initial receiving medium (e.g. a tank rupture and resulting soil contamination).

Next, the transport processes which move contaminants through the environmental media are identified. The direction and rate of contaminant migration are determined and areas that contaminants have been or may be transported to are identified. The environmental fate estimation procedures are based on the predominant mechanisms within each medium. Transformation and degradation (e.g. hydrolysis, oxidation and biodegradation) should be considered as well as intra-media contaminant movement (e.g., sorption, sedimentation, and volatilization).

Finally, exposure points and exposure routes are identified by determining if and where potentially exposed populations can contact contaminated media and how the population could be exposed. Exposure routes (e.g. ingestion, inhalation, dermal) should be based on the media that are contaminated and anticipated activities of the receptor population at the exposure point.

Step 3 Quantification of Exposure. In this last step, the risk assessor quantifies the magnitude, frequency and duration of exposures for each complete pathway identified in Step 2. This is done by estimating exposure point concentrations and calculating intakes for each chemical.

Exposure Point Concentrations (EPC). In general, the concentration term used in the intake equation is the average concentration contacted over the exposure period. The average is represented by the 95% upper confidence limit of the mean contaminant concentration. The following methods should be exercised in evaluating exposure concentrations at a facility:

- Data collected at a facility should be evaluated to determine if distinct zones or areas exist which display similar concentration values. The PRP or his consultant should coordinate with the Department when attempting to delineate concentration zones.

- If specific areas or zones can be defined as having elevated concentration values (where the majority of values exceed the detection limit) for a particular chemical agent or agents, the Reasonable Maximum Exposure or "intake" for a particular exposure pathway should be calculated for each zone. The exposure concentration value in zones with elevated concentrations should be calculated based upon the upper confidence limit (the 95th percent

confidence level on the arithmetic mean). In evaluating zones with elevated concentrations, it is not necessary to incorporate concentration values below the detection limit.

- When assessing exposure concentrations in zones with values at or near the detection limit, a value of one-half the detection limit should be used for non-detect (below the detection limit) values. The exposure concentration should be calculated based upon the 95th percent upper confidence limit.

- If a facility yields data in a random fashion where no discernable zones of concentration values exist, then the exposure concentration value should be calculated based upon the 95th percent upper confidence limit for the entire field of study. A value of one-half the detection limit should be used for non-detect values.

In lieu of actual data, modeling is often used to estimate EPCs if the exposure point is spatially different from a sampling point, if concentrations are expected to change over time, or if concentrations are below the detection limit but could be at levels which would cause a toxic effect. (This is often the case for inorganic or pesticide contamination of surface water. For example, the surface water quality standard for silver is 0.1 µg/L and the detection limit is about 5 µg/L. The standard for DDE is 0.001 µg/L and the detection limit is about 0.1 µg/L).

Estimate of Chemical Intakes. Human exposure is estimated in terms of daily intake. The average amount of contaminant ingested or inhaled each day, the chronic daily intake (CDI), is calculated for chemicals of concern in each environmental media. Intakes of a contaminant for the same route of exposure are summed (e.g. ingestion of PCBs from soil, water and biota). Intakes are weight adjusted such that they represent the mass of contaminant intake per body weight per day.

Standard default exposure values used in the intake calculations are listed in Table 4-6.

Since the default values are open to revision, it is worthwhile to check with the Department for any revisions before proceeding with the exposure assessment.

The State and PRPs will calculate the intakes for all routes of exposures that are considered significant or may become significant in the future.

TABLE 4-6

Default Exposure Values

Target Cancer Risk	1.00×10^{-5} (specific contaminant)
Target Hazard Index/Quotient Value	1 (unity) (specific contaminant)
Body Weight	Adult: 70 Kg Child: 15 Kg Juvenile: 25-30 Kg
Soil Ingestion*	Adult: 100 mg/day (conservative) Child: 200 mg/day Worker: 100 mg/day (very conservative)
Water Ingestion**	Adult: 2 l/day Child: 1 l/day
Exposure Frequency	Residential: 350 days/year Occupational: 250 days/year
Exposure Duration	Residential: 30 years (6 as child, 24 as adult)
Child Trespasser	Two episodes per week for 39 weeks over six years
Adult Trespasser	May vary but is generally two episodes per week for 39 weeks over six years

* For carcinogens in the soil, water or other media a weight adjusted, combined child/adult exposure may be developed.

** For water, analytes that could volatize may need to be considered in bathing/showering as well as exposure in drinking water.

Reasonable Maximum Exposure: The Department defines Reasonable Maximum Exposure as the highest exposure that is reasonably expected to occur at a site under current or future site uses. PRPs may utilize alternative exposure assumptions from those established by the Department if they demonstrate that the default reasonable maximum exposure scenarios specified are not appropriate for a particular site. The use of an alternate exposure scenario must be approved by the Department.

Individuals or groups of individuals may be exposed to hazardous substances through more than one exposure pathway. For example, a person may be exposed to hazardous substances from a site by drinking contaminated groundwater, eating contaminated fish, and breathing contaminated air. At sites where the same individuals or groups of individuals are or could be consistently exposed through more than one pathway, the reasonable maximum exposure shall represent the total exposure through all those pathways. At such sites, the cleanup levels derived for individual pathways shall be adjusted downward to take into account multiple pathways.

4.3.4.3 Toxicity Assessment

The process of characterizing the relation between the dose of chemical received and the incidence of an adverse health effect in exposed populations is called toxicity assessment.

Toxicity assessment is the result of considerable laboratory research. The dose-response relationship for non-carcinogens is expressed as a reference dose (RfD). This is the level or dose of a substance on a long term basis that would not be expected to cause any adverse or harmful response.

The dose-response relationships for carcinogens is expressed as the slope factor. This factor represents the probability of cancer formation as the result of long-term exposure to a given carcinogen.

The RfD and slope factor values are determined by the U.S. EPA and published in databases. The databases are titled Integrated Risk Information System (IRIS) and in Health Effects Assessment Summary Tables (HEAST). New values are calculated from time to time based on new research data. Values become available for additional chemical substances or values are revised for chemical substances on a regular basis. The most current values should be used for risk assessments. IRIS has the most current values and supersedes all other toxicity sources.

4.3.4.4 Risk Characterization

Risk characterization is the final step of the risk assessment. It is the process of estimating the incidence of health effects under various conditions of human exposure as described in the exposure assessment. Risk characterization is performed by combining the dose-response evaluations derived from published sources and the estimated dose from the exposure assessment.

Non-Carcinogenic Effects. The hazard index (HI) approach evaluates overall potential non-carcinogenic effects (assuming multiple chemical detections). The approach assumes that sub-threshold exposures may be additive and/or synergistic. The adverse effect magnitude is proportional to the sum of the ratios for sub-threshold exposures. The Department or the PRPs calculate the hazard indices for each receptor for chronic and/or sub-chronic exposures. If the calculated hazard index exceeds unity, indicating that potential risk exists, the individual compounds detected at the site are segregated and the Department or the PRP calculate individual hazard indices for each target organ for children and adults, individually and then combine these indices to obtain a lifetime HI.

Potential Carcinogenic Effects. For potential carcinogenic effects, risks are estimated as probabilities. The carcinogenic slope factor, which is the upper 95 percent confidence limit on the probability of response per unit intake of a chemical over a lifetime, converts estimated intakes directly to increased incremental risk. For low intakes, most likely encountered from environmental exposures, the carcinogenic risk is equal to the Carcinogenic Daily Intake times the Carcinogenic Slope Factor. The product is generally an upper bound estimate. The Department assumes that cancer risk from various routes of exposure, i.e. ingestion, absorption, inhalation, are additive. Therefore, the Department or the PRPs should report individual (single route of exposure) and aggregate (all routes of exposure) risks for children and adults, and then combine these risks to obtain total aggregate lifetime risks.

4.3.4.5 Uncertainty Evaluations

Risk assessments and public health evaluations incorporate numerous assumptions and utilize empirical data, generally during fate and transport scenarios and intake determinations.

Therefore, the report must describe the risk assessment's major assumptions and uncertainties and determine if these will result in overestimation or underestimation of risks.

The risk assessment process follows the general guidance of the U.S. Environmental Protection Agency as described in the following documents.

- EPA, 1989b. U.S. Environmental Protection Agency, Document 54/1-89/002, Risk Assessment Guidance for Superfund Program. Human Health Evaluation Manual. Part A. Interim Final. December 1989.

- EPA, 1991, Human Health Evaluation Manual, Supplement Guidance: "Standard Default Exposure Factors," May 25, 1991, OSWER Directive 9285.6-03.

- EPA, 1989c. U.S. Environmental Protection Agency. Exposure Factors Handbook. May 1989. EPA/600/8-89/043.

4.3.5 Ecological Assessment

A baseline ecological risk assessment is a qualitative and/or quantitative appraisal of the actual or potential effects of a hazardous waste site on plants and animals other than human and domesticated species. Effects may be manifested as a result of habitat alterations, exposures to potentially toxic substances, or other stress agents at the individual, community, or population level.

In general, ecological risk assessments follow the same general outline as assessments for human health impacts and include sections on:

- Site or Ecological Characterization
- Data Evaluation to Identify Chemicals of Concern
- Exposure Assessment
- Toxicity or Ecological Effects Assessment
- Risk Characterization

As appropriate, the ecological risk assessment may also include a section on the development of remediation goals.

4.3.5.1 Ecological Characterization

Sometimes called an ecological assessment, the ecological characterization includes compiling information on the location and natural history of the site and conducting field reconnaissances. The purpose is to identify and locate habitats and biological receptors that are potentially exposed to site-related contaminants. Care must be taken to identify sensitive habitats, such as wetlands, and areas inhabited by threatened, endangered or other protected species.

The information gathered from the ecological characterization may be used to select species of concern for the risk assessment. Species of concern are selected based on potential for/susceptibility to exposure; status as endangered or threatened, or of special concern; dominance and trophic status; and uniqueness to local region. Consultation with the Department, U.S. Fish and Wildlife Service, local universities, and local biologists or naturalists may be required to ensure that species most significant to the local ecosystem are included in the list of species of concern.

4.3.5.2 Identification of Chemicals of Concern

In this phase, a subset of indicator chemicals from all chemicals found at the site is selected for further evaluation. Chemicals of concern (COCs) are medium-specific and are based on the frequency of detection; the physical and chemical properties of the contaminants (considering persistence in environmental media and ability to bioconcentrate or bioaccumulate); the known or suspected toxicity of contaminants; and the susceptibility of the species of concern.

The selection process is often performed in a tiered approach. The first tier is an evaluation of frequency of detection. The second tier encompasses an evaluation of toxicity and bioconcentration potential. Relative toxicity of contaminants can be screened by comparing maximum concentrations

in individual media with conservative "benchmark" values such as State of Delaware's *"Surface Water Quality Standards"* or the USEPA's proposed ambient sediment quality criteria.

Bioconcentration/bioaccumulation potential is usually based on estimated bioconcentration factors (BCFs). When BCFs exceed 300, a chemical is generally retained as a COC, regardless of concentration, due to the potential for the chemical to magnify in food webs and become a hazard.

4.3.5.3 Exposure Assessment

For a chemical to pose an ecological risk, it must travel from the source of contamination, through environmental media, to the exposure point, and reach ecological receptors in biologically significant concentrations. The pathway must be complete or there is no exposure. Terrestrial, wetland, freshwater, estuarine and marine species can potentially be exposed to chemicals of concern through food, soil, sediment, water, air, or discharge of groundwater.

The actual routes of exposure depend on site conditions and exposure pathways. All actual and potential exposure pathways should be identified, taking into account environmental fate and transport through both physical and biological means. The RI yields information on the current location and concentration of contaminants. Fate-and-transport models predict the movement of contaminants from the source to and between media.

Lastly, the extent of exposure of each species of concern to each of the chemicals of concern should be evaluated. Generally this is done using exposure point concentrations which are either measured or estimated using assumptions and/or fate and transport modeling. The actual dose a receptor absorbs is difficult to estimate since it depends on many factors including the physical and chemical properties of the contaminant (e.g. solubility), the way the receptor assimilates it, the life cycle state of the receptor and the physical/chemical properties of the media (e.g., pH, hardness, organic carbon content). For these reasons if more quantitative information is required to measure effects, then actual biota sampling is required.

If a contaminant is known to bioconcentrate or bioaccumulate, either literature-based BCFs or direct sampling of biota is used to predict the food chain transfer of contaminants to organisms at higher trophic levels. Sampling of biota should take place at two or more trophic levels in combination with sampling of surrounding media to indirectly calculate site-specific BCFs or bioaccumulation factors.

4.3.5.4 Ecological Effects Assessment

This part of the risk assessment qualitatively or quantitatively links concentrations of contaminants to adverse effects in receptors. Literature reviews (e.g., EPA's IRIS and ACQUIRE databases) field studies, and/or toxicity testing provide this dose-response information.

For simple assessments, it is often possible to use literature-based toxicity reference values which establish toxic benchmark concentrations for environmental media to which environmental data can be compared. For example, the previously mentioned State of Delaware's *"Surface Water Quality Standards"* or the EPA or National Oceanic and Atmospheric Association (NOAA) sediment threshold values may be used to determine potential toxic effects.

Toxicity testing is a more reliable means than literature estimates of toxicity. Toxicity tests include in field or in-situ tests at contaminated locations, laboratory tests with contaminated media on selected indicator organisms, or field studies where abundance and distribution of biota is correlated against contaminant concentrations. Indicator species include earthworms (terrestrial invertebrates); Daphnia or Ceriodaphnia (freshwater invertebrates); fathead minnow (freshwater fish); microtox^{r} (microbial population); mysid shrimp or blue crabs (marine/estuarine); Hyalella Azteca (freshwater benthic invertebrate).

In addition to toxic effects at the individual organism level, environmental contaminants have consequences for populations, communities, and ecosystems. Changes in rates of birth, death, immigration and emigration cause changes in population sizes in the affected area. Population level effects in turn result in changes in community structure and function, by reducing species diversity, simplifying food webs, and shifting competitive advantages among species sharing a limited resource. For this reason, ecological endpoints may also be important in assessing the ecological effects of a hazardous waste site.

To evaluate such impacts, field studies are conducted comparing observations of population on site to a carefully selected reference area. Prior to conducting a field study, appropriate ecological measurement endpoints must be selected as the objectives for the study. These include: population abundance; age structure; reproductive potential and fecundity; species diversity, food web or trophic diversity; nutrient retention or loss; and standing crop productivity.

Finally, if chemicals likely to bioaccumulate are found to have migrated off-site in significant quantities, the Department may require that the potential for biomagnification in the food chain be evaluated quantitatively using food-web models. Such models require significant amounts of data: site-, chemical-, and target species-specific.

4.3.5.5 Ecological Risk Characterization

Ecological risk characterizations differ in scope depending upon site specific factors and the amount of effort required to adequately characterize site risks or impacts.

If risks are to be determined qualitatively, the risk characterization may detail the sampling data, the information on fate and transport and knowledge of the environmental setting to support and justify the conclusion concerning ecological risks.

Further information concerning ecological risk assessments can be found in the following documents.

Framework for Ecological Risk Assessment, EPA/630/R-92/001 1992

State of Delaware Surface Water Quality Standards

NOAA Technical Memorandum NOS OMA 52, Long E.R. and L.G. Morgan, 1989.

Risk Assessment Guidance for Superfund volume II Evaluation Manual EPA/540/1-89-001

Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference, EPA/600/3-89/013

Ecological Risk Assessment Methods: A Review and Evaluation of Past Practices in the Superfund and RCRA Programs, EPA/230/3-89/044

Summary Report on Issues in Ecological Risk Assessments, EPA/625/3-91/018

Biological Criteria, National Program Guidance for Surface Waters, EPA/440/5-90/004

Review of Ecological Risk Assessment Methods, EPA/230/10-88/041

Rapid Bioassessment Protocols for Use in Streams and Rivers. Benthic Macroinvertebrates and Fish, EPA/440/4-89/001.

Procedures for Quantitative Ecological Assessments in Intertidal Environments, EPA/600/3-78/087

Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters, EPA/600/4-90/030

Methods for Evaluating Stream, Riparian and Biotic Control, US Department of Agriculture

Protocol for Bioassessments for Hazardous Waste Sites, EPA/600/2-83/054

If there is potential for significant exposure of ecological receptors, the Department may require that a semi-quantitative estimate of risk be performed using presently accepted methods such as toxicity quotients (TQs). This method compares environmental concentrations to toxic benchmark concentrations derived from toxicity reference values in the literature.

Beyond benchmark exceedances, quantitative risk characterizations are most often weight-of-evidence judgments concerning the probability or magnitude of adverse effects. They generally involve evaluating contaminant concentrations in biota, toxicity test results, field surveys of receptor populations and measures of community structure and ecosystem function. If the data from all these studies support the conclusion that an adverse effect is occurring, remediation may be required.

4.4 Development of Remediation Goals

4.4.1 Human Risk Goals

Conditional Cleanup Levels. Conditional cleanup levels represent concentrations which are protective of human health and the environment under restricted site use conditions. Conditional cleanup levels may be established where the person undertaking the cleanup action can demonstrate that such levels are consistent with applicable state and federal laws, that all practicable methods of treatment are utilized, and that institutional controls are implemented in accordance with other conditions as determined to be appropriate by the Department.

Point of Compliance. The point of compliance is the point or points where cleanup levels established by the Department for a given site shall be attained. The point of compliance shall be the property boundary unless the person taking the cleanup action can demonstrate that compliance at the property boundary is excessively restrictive and impractical to obtain. A conditional point of compliance may be established by the Department and shall meet a minimum of one of the following criteria:

- The point of receptor exposure; and/or

- The boundary of a zone of noncompliance as established by the Department. This criteria applies if the point of receptor exposure is farther from the contaminant source than the Department deems to be reasonable.

4.4.2 Ecological Risk Goals

The method of determining remediation goals for ecological risks depends upon the nature of the assessment as well as site-specific conditions. Remediation goals for protection of ecological receptors can be generated from the benchmark values. For example, if a target TQ of 1 is selected for protection of aquatic organisms, exposures for ecological receptors cannot exceed chronic ambient water quality criteria. Alternatively, a food web model could be used to estimate media concentrations which would protect organisms feeding at the top of the food chain from receiving toxic exposure via biomagnification.

Often data from the assessment itself point to appropriate remedial goals; e.g. toxicity tests for certain levels of contaminated media may show little adverse effect. Finally, additional questions concerning the remediation must be considered:

- When contaminants are removed, how long will it take for repopulation to occur?
- Will contaminants move beyond the current study area as a result of remediation?
- What do the data indicate as to the rapidity of response required?
- How will remediation affect future, more thorough remediation, follow-up assessments, and/or use of resources?

Such questions can only be answered by the "best judgment" of qualified ecologists, yet are necessary to fully evaluate remedial goals for demonstrated ecological risks.

4.5 Remedial Investigation Report

Following completion of the remedial investigation and risk assessment, a report describing the work completed and the results is prepared in draft form and submitted to the Department for review. An example outline for an RI report is provided as Appendix C. The model outline should be modified to reflect the conditions and work completed at the site.

The risk assessment report must follow the outline in Appendix C and contain the following:

1. Environmental data summary sheets including, if applicable, the different values used to differentiate multiple zones of contamination;
2. Intake calculations and assumptions;
3. The toxicity values for each chemical of concern; and
4. The risk assessment summary sheets.

A bibliography of the references used in writing the report as well as text supporting the analysis and conclusions shall be included. The risk assessment should include spreadsheets showing the exposure and risk calculations. Conclusions and limitations of analysis as well as comparison to applicable standards should also be stated. The risk assessment report is included as a section of the RI report or may be submitted as a separate document.

Following the quantification of risk related to site contamination during the remedial investigation and risk assessment, an appropriate remedial action plan must be developed for the site. This involves the development of remedial action objectives and the performance of a feasibility study to evaluate the numerous remedial technologies that are available for each medium and contaminant. Remedial alternatives may be combined to address contamination on a site-wide basis. A remedial action plan, describing the preferred remedial alternative, is then developed and advertised to the public during a public comment period. Implementation of the remedy, as described in Chapter 6, occurs once the remedial action plan is finalized. This chapter discusses the requirements for developing remedial objectives, the feasibility study and the remedial action plan.

The results of the baseline risk assessment may indicate that the facility does not pose an unacceptable risk to human health or the environment. In this instance, the FS should either be scaled down or eliminated altogether. The RI and risk assessment serve as the basis of a No Action Remedial Decision Record. The decision to modify or eliminate the scope of the FS must be made with Department approval.

5.1 Remedial Action Objectives

Upon completion of the remedial investigation and risk assessment, the PRP or the Department shall establish specific remedial action objectives for the areas affected by the release or imminent threat of release of hazardous substances. The remedial action objectives shall consider:

- Current and potential uses of the land and/or natural resources
- Use and level of contamination of surrounding properties.
- Facility specific human health and ecological risk assessment
- Applicable local, state and federal laws and regulations.

Both qualitative and quantitative remedial action objectives should be developed. Remedial action goals should be specific to each site medium. Goals are generally developed by reviewing the conceptual model of contamination presented in the RI in light of the hazards identified in the risk assessment and any applicable requirements.

5.1.1 Applicable Requirements

HSCA regulations require that applicable requirements be used to guide development of remedial action objectives, to evaluate remedial alternatives and to govern the implementation and operation of the selected remedy.

Applicable requirements are defined as all local, state and federal environmental laws and regulations such as cleanup levels, standards of control, and other environmental protection requirements, criteria,

or limitations promulgated under federal or state law that specifically address a hazardous substance, cleanup action, location, or other circumstances at the facility.

The regulations also stipulate that applicable requirements may receive a regulatory variance if the substantive conditions of the requirement are met. In all such cases, remedial actions must still be protective of public health and the environment.

Applicable requirements for remedial action are generally classified into one of the following three functional groups:

- Chemical-specific (i.e., requirements that set protective exposure levels for the chemicals of concern);

- Location-specific (i.e., requirements that restrict remedial actions based on the characteristics of the site or its immediate environs, i.e., zoning); and

- Action-specific (i.e., requirements that set controls or restrictions on the design, implementation, and performance of activities related to the management of hazardous substances, pollutants, or contaminants).

5.1.1.1 Chemical Specific Applicable Requirements

Chemical-specific requirements set health or risk-based concentration limits or ranges in various media for specific hazardous substances. These requirements provide protective site exposure levels (as a basis for calculating cleanup levels) for the chemicals of concern in the designated media. Chemical-specific requirements are also used to indicate an acceptable level of discharge to determine treatment and disposal requirements that may occur in a remedial activity, and to assess the effectiveness of the remedial alternative.

5.1.1.2 Location Specific Applicable Requirements

Location-specific requirements set restrictions on the types of remedial activities that can be performed based on site-specific characteristics or location. Remedial action alternatives may be restricted or precluded based on federal and state siting laws for hazardous waste facilities, proximity to wetlands or flood plains, or presence of endangered species or cultural resources. Location-specific requirements must be addressed during the formulation and evaluation of potential location-specific remedies.

5.1.1.3 Action Specific Requirements

Action-specific requirements are triggered by the particular remedial alternatives that are selected to accomplish the cleanup. These action-specific requirements may include, for example, hazardous waste transportation and handling requirements, water discharge standards, and the RCRA landfilling and treatment requirements. In addition, local building regulations may be triggered, depending on the remedy selected.

5.1.2 Qualitative Objectives

Qualitative remedial action objectives are presented in general terms and describe the ultimate results that remediation at the facility should achieve. They address the future use of the facility and specific threats to public health, welfare and the environment that must be considered, but in non-quantifiable terms such as "non-degradation", "prevention of trespassers", or "restoration of habitat".

5.1.3 Quantitative Objectives

Quantitative remedial action objectives arise from risk assessment and/or applicable requirements which specify an acceptable contaminant level or range for each medium that may remain after completion of the remedy.

The preliminary remediation goals that were developed in the RI and the chemical-specific ARs may need to be adjusted to match specific remedial action objectives and/or site conditions. For example if there is a complex "soup" of contaminants at the site to which the public may be exposed through many pathways, a limit that was set based upon meeting an acceptable risk level for a single contaminant under only one pathway may not be protective.

5.1.4 Volumes of Contaminated Media

After developing qualitative and quantitative remedial action objectives for the facility, the extent of media requiring remediation must be defined. This requires careful judgement and should include a consideration of not only acceptable contaminant levels, but also site conditions, the nature of the contamination, and engineering feasibility. For example, if contamination can be easily contoured such that the border between "clean" and contaminated material is defined or when some physical barrier defines the contamination, volume definition is straightforward. However, if contamination is found in discrete hot spots randomly scattered throughout a site such that sampling data may not define all areas requiring remediation, the volumes of contaminated media are more difficult to define and may have to be approached by a "volume vs. concentration" relationship or statistical method. If these approaches are undertaken, the resulting remedy should be reviewed to ensure it is still protective of public health, welfare and the environment.

5.2 Feasibility Study

The objective of the feasibility study is to develop a range of remedial alternatives which meet the site's remedial action objectives from which to select the appropriate remedial action. The EPA has developed specific steps that may be followed during the performance of a feasibility study and has presented them in "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA", EPA 1988. The approach presented in this guidance document is distilled from EPA guidance in an effort to make the process more streamlined and its level of detail more reflective of typical site conditions. In some cases, a focused feasibility study involving a limited number of remedial alternatives or use of a presumptive remedy is acceptable to expedite remedial response. This often occurs if a response at a facility is divided into operable units or if outside circumstances pose restrictions on the time period allowed for implementing the remedy. In such cases, a focused feasibility study can be conducted which limits the universe of remedial alternatives to a single medium

or to applicable time constraints, etc. Department approval is required before initiating a focused feasibility study. The three basic components of the feasibility study are:

- Development of remedial alternatives;
- Screening of remedial alternatives; and
- Detailed analysis of remedial alternatives.

The amount of effort required for completion of each of these components, and the extent to which they need to be completed, will vary depending on the site-specific issues, contaminants characterized and media involved. In general, a wider range of alternatives will be necessary to address multi-media contaminant sites. For such sites, the screening and evaluation processes required to select a remedial alternative are necessarily more complex. The next subsections identify all of the steps that could be required to complete the three components of the feasibility study.

5.2.1 Development of Remedial Alternatives

Remedial alternatives address contamination on a site-wide basis and are developed from media-specific remedial technologies and process options. For sites with limited contaminants and extent of contamination, alternative development may be accomplished intuitively. For more complicated sites, it may be advantageous to use formal procedure which focuses on identifying all alternatives and selecting those that are deemed most effective. To minimize the effort associated with the process, alternatives should be progressively evaluated and screened. The process involves the following steps:

- Identification of remedial response actions;
- Identification and screening of remedial technologies and process options; and
- Development of remedial alternatives.

5.2.1.1 Identification of Remedial Response Actions

Remedial action objectives are used to identify appropriate remedial response actions for the site, which usually include some or all of the following broad categories:

- No Action/Deferral to another program
- Institutional Controls
- Limited Action
- Containment
- Removal/Disposal
- Treatment

Any remedial response which is appropriate for the site should be listed and retained for further evaluation. Identification of these actions as part of the feasibility study documentation should include the specific contamination they are meant to address and the volume or area which exceeds the remedial action objectives for the contamination. A format similar to that shown in Table 5-1 may be used to provide this documentation.

At this stage, response actions that could be immediately implemented should be identified and, if the Department determines they are necessary, an interim action may be required. This interim action would need to be briefly evaluated as to its applicability and feasibility.

5.2.1.2 Identification and Screening of Remedial Technologies and Process Options

Technologies which may be used to implement the remedial response actions are identified and then screened based on technical practicability. Typically, the factors that will determine practicability are the types and concentrations of contaminants (which limit many types of treatment) and onsite characteristics, such as the presence of shallow bedrock. The screening process may be documented through the use of a table as is shown in Table 5-2.

There will often be a number of remedial process options associated with each remedial technology determined to be implementable. These options should be identified, emphasizing the use of innovative approaches wherever possible. In order to streamline the alternative evaluation process, the most desirable process option for each technology is identified based on likely effectiveness, operational ease, reliability, and cost. This option will be carried through the remedial alternative selection process and preliminary design. An alternate process option may be selected during remedial design.

This process may be documented through the use of a table as shown in Table 5-3.

If process options within a technology are considered to be different enough to warrant equal consideration, more than one could be retained during the screening process. This increases the number of remedial alternatives to be evaluated, however, and the effort associated with this evaluation. The Department encourages innovative technology development, therefore, all innovative process options should be retained for further consideration.

TABLE 5-1
(SITE)
HSCA FEASIBILITY STUDY
IDENTIFICATION OF REMEDIAL RESPONSE ACTIONS

MEDIA	REMEDIAL ACTION OBJECTIVES	RESPONSE ACTIONS
Surface Soil	10^{-5} risk level	No Action
		Institutional/ Engineering Controls
		Containment
		Treatment
		Excavation/Disposal
Sediments	EPA proposed criteria	No Action
		Containment
		Treatment
		Excavation/Disposal
Groundwater	MCLs or 10^{-5} risk level	No Action
		Institutional/ Engineering Controls
		Containment
		Pump and Treat

TABLE 5-2
(SITE)
HSCA FEASIBILITY STUDY
SCREENING OF REMEDIAL TECHNOLOGIES

REMEDIAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	SCREENING STATUS	REASON FOR SCREENING
Institutional/Engineering Controls	1)Fencing 2)Deed Restrictions	RETAINED	Required by NCP
Containment Action	Capping Dust Control	RETAINED RETAINED	Feasible Feasible
Treatment	Solidify Fixate/ Immobilize	RETAINED	Feasible
	Physical Treatment, Separation by grain size or density	REJECTED	Not feasible with both organics and inorganics
	Vapor Extraction	RETAINED	Applicable if combined with chemical treatment
	Biological Treatment	RETAINED	Applicable if combined with chemical treatment
	Chemical Extraction	RETAINED	Applicable for inorganics

TABLE 5-3
(SITE)
HSCA FEASIBILITY STUDY
SCREENING OF REMEDIAL TECHNOLOGIES

REMEDIAL TECHNOLOGY	PROCESS OPTION	EFFEC-TIVENESS	IMPLEME N-TABILITY	COST	SCREENIN G STATUS
Capping	Soil cover	Allows infiltration	Easy	Low cap., high O&M	REJECTED
	Asphalt/ concrete pavement	Susceptible to cracks	Relatively easy	Low O&M	RETAINED
	Clay cap	Effective and reliable	More difficult	High	RETAINED
Solidify/Stabilize	Pozzolanic agents	Effective and reliable	Difficult	Med	RETAINED
	Neutralization	Not for organic	Easy	Low	REJECTED
	Resin immobilizatio n	Eff. & rel.	Relatively easy	Med	RETAINED
	Vitrification	Eff. & rel.	Difficult	High	REJECTED
Chemical Treatment	Solvent extraction	Eff. & rel.	Difficult	High	RETAINED
	Acid leaching	Eff. & rel.	Difficult	Med	RETAINED
	Neutralization	Not as eff.	Easier	Low	REJECTED
	Oxidation	Not as eff.	Easier	Med	REJECTED

5.2.1.3 Development of Remedial Alternatives

Until this point in the process, the evaluation has focused on specific contaminated areas and the impacted media. In order to develop remedial alternatives, contaminant and medium-specific technologies for each contaminated area may be combined to address site-wide contamination. It is important to retain alternatives that represent the full range of contamination management approaches, from no action to treatment. The most important difference between these approaches is the extent to which they require long term management of site contamination. The no action alternative represents the most significant level of long term management of contamination, while treatment alternatives require the lowest level of long term management. These two extremes of the alternative range also provide baselines for comparison with other alternatives.

The approach used to identify the technology combinations may be either informal, such as through brainstorming, or formal, such as the use of a matrix. Once identified, the alternatives need to be developed in enough detail so that subsequent screening and detailed evaluation of them may occur on a consistent basis. This should include a conceptual design of the various technology components, including:

- Size and configuration of units;
- Timeframe for implementation;
- Rates or flows of treatment;
- Spatial requirements;
- Transportation requirements;
- Permitting requirements; and
- Operation and maintenance requirements.

A description of potential interactions among the technologies selected for various media should also be provided.

5.2.2 Initial Screening of Remedial Alternatives

The final step of the feasibility study will be the detailed evaluation of remedial alternatives. For sites where a large number of alternatives have been developed, it would be very time consuming and repetitive to complete this process for all alternatives. An intermediate screening of alternatives may then be useful. If there are relatively few alternatives (for example, one for each remedial response action per medium), this screening step may not be necessary. It is recommended that the necessity of completing this step be determined by the PRP and discussed with the Department.

The criteria that should be used to screen remedial alternatives include the following:

- Effectiveness in meeting site cleanup levels;
- Appropriate engineering practices based on applicability, feasibility for the site and reliability; and
- Relative cost.

In contrast to previous evaluations which focused on specific media and areas, the screening of remedial alternatives accounts for media interactions across the entire site. Generally, remedial

alternatives that represent a common management approach should be screened against each other. As mentioned previously, alternatives that use innovative technologies should be preserved to the extent possible. Typically, there will not be enough data to develop these alternatives to the same level as established technologies, making consistent screening difficult. No more than 10 remedial alternatives should be carried through for detailed analysis. Typically the number should be closer to five or six alternatives, however this may vary based on site conditions. The screening process must be documented. Depending on the number of alternatives screened, presentation of the screening may be through a table or text format.

It is recommended that the Department be informed of the list of screened remedial alternatives so that any preferences or concerns for detailed analysis are addressed prior to its initiation. This reduces the likelihood that alternatives would have to be added at a later date and the detailed analysis process repeated.

5.2.3 Detailed Analysis of Remedial Alternatives

The objective of the detailed analysis of remedial alternatives is to present the relative advantages and disadvantages of different contaminant management approaches for the site. This is accomplished by evaluating the alternatives against the criteria that the Department will use to make the selection of the preferred alternative. These criteria include the following:

- Protection of public health, welfare and the environment;
- Compliance with applicable laws and regulations;
- Community acceptance;
- Compliance monitoring requirements;
- Permanence;
- Technical practicability;
- Restoration time frame;
- Reduction of toxicity, mobility and volume of contamination;
- Long-term effectiveness; and
- Short-term effectiveness.

For alternatives which equally satisfy these criteria, the capital and operation and maintenance cost effectiveness will be evaluated and used to establish preference.

The aspects of each criteria that should be considered during alternative evaluation are shown in Table 5-4. This evaluation may be completed as a one- or two-step process. If the alternatives are relatively straightforward, they may be compared against each other for their satisfaction of the criteria directly. For more complex alternatives, a two-step process is recommended where each alternative is evaluated against the criteria and then the alternatives are compared for each criterion. The relative strengths and weaknesses of each alternative on a qualitative or quantitative basis should be highlighted during this process. The degree to which uncertainty about site conditions and the alternatives may influence the evaluation process should also be identified.

Documentation of the comparative analysis process must be provided. If the individual alternative analysis is completed, it may be effectively presented in tabular format. Presentation of the comparative analysis is typically in text form and organized by criteria, with the alternatives described in order of decreasing preference.

5.2.4 Presumptive Remedies

Some facilities have contamination problems that point directly to a proven remedial technology before the investigation even begins. This occurs when the site falls into one of several common categories where remedy selection has followed a typical pattern and scientific and engineering evaluation of the performance data from the operation of the remedy have demonstrated it is the preferred remedy for that category of site contamination. In these situations, the Department will consider the presumptive remedy approach to the remediation where the investigation is focused to obtain only as much information as needed to support development of the remedy that is presumed to be required. This will significantly reduce the costs of the RI and the technology evaluation phase of the FS.

5.2.5 Feasibility Study Report

The PRP must summarize the decision-making process and provide justification for the evaluation process in a report. An outline for a feasibility study report is provided as Appendix D. The outline may be modified as necessary to reflect site conditions and the level of detail of the feasibility study. The report should be submitted in draft form for Department review. Once the Department's comments are incorporated, the PRP will issue a final feasibility study report.

TABLE 5-4
HSCA CLEANUP PROCESS
FEASIBILITY STUDY
CRITERIA FOR DETAILED ANALYSIS OF ALTERNATIVES

CRITERIA	CONSIDERATIONS
Overall Protection of Public Health, Welfare, and the Environment	Attains compliance cleanup levels; and conditional cleanup levels.
Compliance with Laws and Regulations	Federal, state and local; Chemical-specific; Action-specific; Location-specific; and Other guidance.
Community Acceptance	Desired use of property after remediation; Historical issues related to site; and Public concerns about remediation.
Remediation Monitoring	Requirements for compliance monitoring; Ability to monitor success of remediation; Exposure pathways that cannot be monitored; and Consequences of failed remedy.
Permanence	Amount of contamination destroyed; Amount of contamination treated; Degree to which treatment is irreversible; Residuals remaining after treatment and associated risk.
Technical Practicability	Likelihood that technologies will meet performance specifications; Ability to construct and implement technology; Reliability of technology; Ease of undertaking additional remedial actions if needed; Availability of services; Availability of equipment and specialists; and Availability of technologies.
Restoration Time Frame	Time until principal threats are addressed; Time until secondary threats are addressed; and Time until remedial action objectives are met.
Reduction of Toxicity, Mobility and Volume of Contamination	Mitigation of principal risks at site; Special requirements for treatment process; and Extent toxicity, mobility and volume reduced.
Long-term Effectiveness	Contamination remaining on-site and associated risk; Treatment residuals and associated risk; Type and degree of long-term management; Difficulties associated with long-term management; and Potential for alternative failure and associated risks.
Short-term Effectiveness	Protection of community during implementation; Protection of workers during implementation; Environmental impacts expected during implementation; and Available mitigation measures.

5.3 Plan of Remedial Action

After selecting an alternative for the site based on the process described above, the Department prepares a proposed plan of remedial action. The contents of the proposed plan are site specific and may include some of the following information:

- Description of the remedial alternative and compliance monitoring;
- Summary of other alternatives considered and why not selected;
- Cleanup levels and point of compliance for each medium;
- Schedule for implementation of the plan;
- Institutional controls required; and
- Applicable state and federal laws.

Once the proposed plan is prepared, it is made available to the public for review and comment. The Department issues a public notice describing the facility and the proposed plan. Comments are invited from the public for a period of no fewer than 20 days after the date of public notice. After review of the comments, the Department issues a final *plan of remedial action* for the site. The final plan shall be incorporated into a remedial decision record.

The Remedial Decision Record consists of the proposed and final plans of remedial action and any information necessary to support conclusions contained in the plans. In addition, the Remedial Decision Record contains all written comments received by the Secretary and a response summary to those comments.

Section 6
Implementation of Remedy

The Department or the PRP with the Department's oversight may conduct and implement the remedial alternative identified in the final plan of remedial action. If the PRPs elect to conduct the work with Departmental oversight, the PRPs must enter into a consent decree with the Department. The consent decree agreement details the terms and conditions of the implementation of the remedial design, remedial action, and operation and maintenance phases of the remedy.

A four party team is typically involved in the implementation of the remedy. Generally, the team consists of the PRP, the Department, the engineer, and the contractor. The PRP is responsible for financing and directing the remedy implementation, while the Department provides oversight. The engineer usually is responsible for the remedial design portion of the process, and may be retained to provide construction oversight during remedial action. The engineer is contracted directly by the PRP for completion of these tasks. The contractor is responsible for the implementation of the remedy under PRP or engineer direction and contract. Other contractors may and typically are hired to perform aspects of the design, construction and maintenance.

6.1 Consent Decree

The consent decree is an agreement by the Department and the PRPs whereby the PRPs commit to finance and perform the remedial design and remedial action. The components of a consent decree are listed in Table 6-1.

6.2 Remedial Design

The remedial design details and addresses the technical requirements of the remedial alternative to be implemented. Remedial design is a multi-step process beginning with preliminary design and ending with completion of a detailed set of engineering plans and specifications. This section describes the requirements for selection of the remedial design engineer, design document submittal requirements, and community relations during the remedial action process.

The level of detail required for the remedial design depends on the specific site conditions, number of areas and contaminants to be remediated, and the complexity of remediation. There are two approaches to remedial design: performance-based and definitive. In a performance-based design, basic technical specifications are developed which contain the performance requirements for the work. The design engineer focuses on defining criteria and process limits. It is then the remedial action contractor's responsibility to implement a remedial plan that achieves those technical specifications. In a definitive design, information is provided on system

TABLE 6-1
HSCA CLEANUP PROCESS
CONSENT DECREE COMPONENTS

COMPONENTS	DESCRIPTION
Introductory Sections	• Statement that the consent decree is entered into voluntarily by the Department and the PRP. States overall objective of the consent decree. • Authority of the Department to enter into the consent decree. • Agreement by PRP not to contest the authority or jurisdiction of the Department or the validity of the agreement or its terms. • Parties bound by the consent decree (PRP, its agents, successors, assigns, officers, directors and principles. • Notice of obligations to successors-in-title.
General Provisions	• Objectives of the Department and the PRP in entering into the consent decree. • Requirement that activities conducted are subject to approval by the Department and shall be conducted in compliance with HSCA and applicable Department guidances, policies and procedures. • Findings of Fact identifies the site and provides information regarding site history and activities that have already taken place. • Conclusions of law defines the site, hazardous substances, release, person, and PRP under HSCA. States that the actions required by this consent decree are necessary to protect public health or welfare, or the environment. • Applicability of definitions provided in HSCA and the Regulations to the consent decree. • Identifies the actions agreed to be performed by the PRP, i.e. remedial investigation and feasibility study, remedial design and remedial action. In this section, the Work Plan is appended to and made an enforceable and integral part of the Consent Decree.
Work To Be Performed	• Requirement that all work to be performed will be done under the direction and supervision of qualified personnel and in accordance with the Work Plan. Requirements that PRP notify the Department of any changes in personnel. • Requirement that PRP conduct activities and submit deliverables as provided in the Work Plan. • Right of the Department to comment on, modify, and direct changes for all deliverables. • Right of the Department to stop PRP from proceeding further on any task, activity or deliverable at any point during the performance of work under the consent decree. • Right of the Department to seek penalties, conduct activities and seek reimbursement of expenses when performed after refusing approval of a revised submittal by a PRP. • Requirement that the PRP incorporate any information supplied by the Department for work performed by the Department into its final reports. • Approval rights of the Department. • Requirements of notification to the Department prior to any off-site shipment of hazardous substances from the site to an out-of-state waste management facility. • Requirements for modification of the Work Plan. • Quality Assurance must conform to requirements of the Work Plan.

TABLE 6-1
HSCA CLEANUP PROCESS
CONSENT DECREE COMPONENTS
(Continued)

COMPONENTS	DESCRIPTION
Reporting Requirements	• Responsibility of Department to prepare and/or release information to the public, i.e., final reports, proposed plan, public comment, remedial decision record • Requirements for PRP submission of progress reports and participation in meetings. • Requirements for sampling, access, and data availability/admissibility
Other Conditions and Requirements	• Designation of project officers for Department and PRP with rights to change project officers. • Procedures for dispute resolution • Penalties for failure to make timely submittals • Requirements for extensions of schedules • Requirements for obtaining permits • Provisions for circumstances which create a danger to the health or welfare of the people on or around the site.
Reimbursement of Costs/Claims	• Requirements for reimbursement of past costs incurred by the Department. • Reimbursement of response and oversight costs incurred by the Department after the effective date of the consent decree. • Reservations of rights and reimbursement of other costs. • Parties rights to bring an action against anyone not a signatory to this consent decree.
Concluding Sections	• Applicability of local, state and federal laws and regulations. • Requirements for records preservation. • Requirements for financial assurance, insurance and indemnification • Agreement of enforceability of the consent decree • Requirements for amending the consent decree. • Binding of consent decree on successors and assigns. • Termination and effective dates of the agreement.

integration and on appropriate equipment for each unit process. The engineer chooses equipment, dimensions, controls, size, shape, materials, and installation details. The contractor then builds to those definitive plans and specifications.

In many situations, a mixed design approach is used. This often occurs for designs incorporating an innovative or emerging technology for which there is relatively little information available. In these instances, the engineer may use a performance specification for the innovative technology and a definitive design for all other aspects.

6.2.1 Remedial Design Engineer Selection

The selected remedy may include an architectural and/or engineering component beyond the capability of the environmental consultant used for the RI/FS phase of the project. The engineer may, therefore, not be the same as the engineer who prepared the remedial investigation and feasibility study. The general approach described for the selection of a consultant in Chapter 4 may also be used to evaluate and select the remedial design engineer. The Department reserves the right to approve or disapprove any engineer in accordance with the *Minimum Qualification Requirements for Consultants/Contractors Performing Work Under the Delaware Hazardous Substance Cleanup Act.* The specific responsibilities of the engineer during the design phase should be evaluated in the selection process. The following components of design should be considered:

- Evaluate and interpret information generated in the RI/FS and during the planning phase, such as treatability study data and geotechnical investigations;
- Collect and evaluate additional data requirements for the design phase;
- Provide complete engineering designs, plans, and specifications of the remedial action to be constructed;
- Identify and obtain easements, permits and approvals necessary for the remedial action;
- Provide design documents and specifications concerning compliance with design requirements for department review and approval; and
- Update plan(s) and specification(s) changes during construction.
- Prepare permit documents

6.2.2 Remedial Design Submittals

The preparation of A number of submittals require Departmental review during remedial design. The first document is typically the remedial design work plan. The work plan describes the work necessary to complete the design of the remedy as set forth in the plan of remedial action and in accordance with the Scope of Work in the consent decree. The work plan includes descriptions and schedules for the implementation of all remedial design and pre-design tasks identified in the Scope of Work. Remedial design involves preparation of the following documents which may be submitted as one report in order to avoid unnecessary duplication and reduce the review schedule. An example outline for a remedial design report is provided as Appendix D.

1) Engineering design report - This report contains information as required by the Department and approved in the remedial design work plan. The types of information that the Department requests may include the following:

- Description of the facility;
- Description of the remedial action being designed;
- Engineering calculations, criteria and assumptions used in preparing the design;
- Treatability study and pilot test results used in the design;
- Lists of permits and regulatory approvals needed for remediation;
- Proposed schedule for implementation of the remedial action tasks and reports; and
- Discussion of other relevant technical factors.

2) Construction plans and specifications - This submittal details the elements of the remedial action to be performed and must be prepared in accordance with currently accepted engineering practices. Plans and specifications are typically submitted to the Department in stages and may include preliminary, intermediate and final design submittals. During each stage, the Department comments on the submittal and requests changes as needed to conform to the remedial work plan and consent decree. The subsequent submittal should incorporate those comments. The content of the construction plans and specifications is dependent on the conditions of each site and the remedial action to be implemented. In general, the submittals will include the following:

- Design plans and specifications;
- A field sampling plan which defines in detail the sampling and data gathering methods to be used during project construction;
- A construction quality assurance plan which describes the site specific components of quality assurance during construction. The objective of this plan is to ensure with a reasonable degree of certainty that the completed project meets or exceeds all design criteria, plans, and specifications; and
- A Health and Safety plan that details procedures to be followed in the event of an accident or emergency at the site to protect the local public.

3) Operation and maintenance plan - The operation and maintenance plan describes the activities necessary to ensure the long-term effectiveness of the remedial action. The basic elements of an operation and maintenance plan are provided as Appendix E to this manual. A compliance monitoring component to the Operation and Maintenance plan may be added if ongoing treatment or mitigation efforts are part of the remedial action. Compliance monitoring measures progress toward allowing cleanup levels and ensuring long-term effectiveness of the remedy.

6.2.3 Community Relations

Community relations is an important element in the successful implementation of remedial action at the site. The Department and PRPs should prepare fact sheets in concert and discuss remedial design concerns with interested parties. Prior to construction, the Department and the PRPs should provide a public briefing near the site, to address issues such as construction schedules, traffic patterns, locations of monitoring equipment, public information outlets, and any other information relative to remedy construction.

6.3 Remedial Action

Following approval of final design documents, implementation of the remedial action proceeds. Implementation requires the preparation, submittal and approval of a remedial action work plan by the PRP. All work conducted during the remedial action shall be in accordance with the work plan and the construction quality assurance plan. The PRP should initiate a pre-construction conference prior to the start of construction. Participants should include representatives from all parties involved in the remedial action and the conference should review all aspects of remedy construction.

Although the responsibility and accountability for remedial action remains with the PRPs, the Department is heavily involved during the remedial action to ensure that the work is completed in accordance with the consent decree and design documents. This is accomplished by the Department designating a project manager for oversight. The PRP contracts with a remedial contractor to perform the remedial work and a resident engineer to provide oversight. The oversight engineer for the PRP establishes an independent quality assurance team with Department approval.

6.3.1 Remedial Action Work Plan

The remedial action work plan is the basis for the PRP's approach to implementation of the remedial action. It is the responsibility of the PRP to prepare the work plan. The PRP usually contracts this task to the design engineer. The work plan is reviewed and approved by the Department and must address the following:

- Tentative identification of key personnel, description of duties and roles, lines of authority in the management and implementation of remedial action;
- Process for selection of a remedial action contractor;
- Remedial action schedule and the process for continuous project updates;
- Methods for implementing the construction quality assurance plan;
- Health and safety plan for field construction activities;
- Strategy for implementing the contingency plan;
- Procedures for data collection during remedial action to validate project completion; and
- Requirements for project closeout.

6.3.2 Department's Role

The Department monitors the PRP's compliance with the consent decree and all other documents and plans during remedial action implementation. The role is diverse and multi-faceted and includes the following:

1) Conducts periodic progress meetings with PRPs to address status changes, schedule changes, project construction status, observations and findings, issues of non-compliance, change orders, and upcoming activities.

2) Monitors the PRP's construction activities and adherence to the HASP. Ensures activities are not endangering public health, welfare or the environment.

3) Monitors construction quality assurance program.

4) Coordinates interaction among all government entities.

5) Promotes community relations (e.g. site visits).

6) Documents contacts with PRPs during the remedial action.

7) Verifies completion of work required under consent decree and initiates project closeout.

8) Ensures PRP's compliance with consent decree.

6.3.2.1 Project Manager

The Department's project manager monitors compliance by the PRPs with the consent decree, the plans and specifications, and the construction quality assurance and quality control plan. The project manager may use a high level of oversight at the onset of remedial action as determined by requirements in the consent decree, the complexity of the design, past performance of the PRPs and/or their construction contractors and any other factors affecting remedial action implementation. The oversight officials can adjust the oversight level as remedial action proceeds based on the actual performance of the PRPs and their construction contractors. Oversight may include the following:

1) Attending the pre-construction conference, progress briefings, and any other meeting as required.

2) Making on-site work progress observations to determine if work is generally progressing as scheduled/anticipated in accordance with the plans and specifications and the construction quality assurance and quality control plan. The project manager monitors the PRP's quality assurance program.

3) Immediately notifying the authorized remedial action contractor or PRP of any observed imminent or substantial endangerment to public health, welfare and the environment, and following up with an appraisal to the Department.

4) Reviewing any actions that the contractor or PRP takes in interpreting contract documents in a way that may materially affect the work in progress or intent of the plans and specifications and taking appropriate steps.

5) Reviewing change orders, work directives, contract modifications made by the remedial action contractor for consistency with the consent decree.

6) Reviewing contractor's progress reports and scheduling.

7) Maintaining a diary or log of field observations including interactions with all parties, test results, site visits, and questions, concerns, or discussions about conformance with approved design plans and specifications.

8) Reviewing perimeter monitoring data to determine action level exceedances and verifying prompt corrective actions.

9) Reviewing certificates, operations and maintenance manuals, and other data required to be assembled and furnished by the contractor.

10) Attending pre-final/final inspections and reviewing punch list items and verifying that punch list items have been completed or addressed.

11) Reviewing deliverables (e.g. remedial action work plan, construction quality assurance quality control plan, and project closeout report) submitted by PRPs.

6.3.3 Independent Quality Assurance Team

Depending on the scope of the project, the Department may require that construction quality be verified by an independent agent. The independent quality assurance team is used to provide a certain level of confidence in the remedial action by selectively testing and inspecting the contractor's remedial action work and ensuring the implementation of the construction quality control plan. The independent quality assurance team may be a separate consultant working for the PRP under a contractual relationship or it might be "in-house" personnel assigned to the project. The independent quality assurance team implements the activities specified in the construction quality assurance plan. Typical activities include:

1) Submitting blind samples for analysis.

2) Confirming regular calibration of testing equipment(i.e. recorded and properly conducted).

3) Verifying testing procedures (i.e. consistent and as prescribed).

4) Confirming that test data are properly recorded, validated, maintained, and interpreted.

5) Reporting quality assurance activity results to the PRP.

6) Providing copies of all test result to oversight officials.

7) Verifying implementation of construction quality control plan in accordance with construction quality control plan.

8) Maintaining communication and coordination with oversight personnel concerning quality assurance results.

The Department reviews and approves the selection of the independent quality assurance team using the following criteria:

1) Evaluation of professional and ethical reputation as determined by inquiries with previous clients and other references.

2) Qualifications and expertise of the inspection personnel should be commensurate with the scope of the project.

3) Confirmation that the quality assurance team is truly independent and autonomous from the remedial action contractor.

6.3.4 Resident Engineer

In addition to design responsibilities, the remedial design consultant may be requested to provide a resident engineer to act as the PRP's agent on the site during construction. In other situations, the resident engineer may be hired from another consulting firm. In either case, this person is critical in establishing and maintaining construction quality on the site. Typically, the resident engineer is required to:

1) Review progress and shop drawing submittal schedules.

2) Serve as the PRP and remedial design engineer's liaison with the remedial action contractor.

3) Maintain, at the site, orderly files of all job records.

4) Log shop drawings and samples.

5) Review work performed, disapprove defective work, and verify that test and start-up procedures are accomplished.

6) Accompany PRP personnel and inspectors, and other agency personnel with a jurisdictional interest during site visits.

7) Prepare periodic progress reports, make recommendations concerning major inspections and tests, draft change orders, field orders, and work directive changes.

8) Prepare a project closeout report which certifies that the completed project has been constructed in accordance with the settlement agreement and that all performance standards have been met.

9) Determine that certificates, operation and maintenance (O&M) manuals, and other required data have been assembled by the remedial action contractor.

6.3.5 Remedial Action Contractor

The remedial action contractor is responsible for implementing the remedial action work plan under PRP and Departmental oversight. The Department reviews and approves the selection of the contractor using the following criteria:

- Evaluation of professional and ethical reputation as determined by inquiries with previous clients and other references;
- Previous experience in the type of construction activities to be implemented; and
- Demonstrated capabilities to perform the specific construction activities required.

6.4 Operation and Maintenance and Compliance Monitoring

Operation and maintenance of the remedial action implemented at the site begins soon after the completion of the construction activities, or when the Department determines that the remedy is performing as designed. Operation and maintenance activities are conducted in conformance with the procedures detailed in the operation and maintenance plan submitted during the remedial design process. Monitoring during the operation and maintenance period measures compliance with remedial objectives, risk reduction goals, and remedial action requirements. Types of monitoring include the following:

1) Monitoring to confirm that public health, welfare, and the environment are being protected.

2) Performance monitoring to ensure that progress toward achieving clean up standards is being made.

3) Monitoring to confirm the long-term effectiveness of the remedial action.

The PRP shall take actions in accordance with the health and safety plan if any event causes or threatens a release that may represent a danger to on-site personnel. If there is a substantial danger to public health, welfare or the environment outside of site boundaries, the PRPs will implement the contingency plan. In all cases, the PRPs must notify the Department. During the emergency,

the Department and oversight officials will closely monitor the situation to determine that health and safety issues are being adequately addressed.

6.5 Certification of Remedy

Following completion of the remedial action at the site, the remedy is eligible for certification by the Department. Certification requires the performance of site inspections, completion of a project closeout report, and an application by the PRP to the Department for a certification of completion of remedy. All remedies require final inspections and closeout reports. Certification is the process whereby the Department memorializes satisfactory completion of the remedy. The PRP must solicit certification.

6.5.1 Inspections

The PRP conducts the pre-final and final inspections of completed work with Department and oversight officials, and other agencies with a jurisdictional interest. The pre-final inspection determines if the PRPs completed all aspects of the remedial decision document. The PRPs develop a punch list of uncompleted items as a result of the inspection. The Department and the oversight officials note all corrective and extra work required to meet the design and specification requirements. The Department compares these notes to the PRP's punch list and includes additional items to the punch list as required. The Department does not grant acceptance of work until the PRPs have met the performance standards of the final plan of Remedial Action and all elements of the remedial design.

The PRPs, the Department, and oversight officials conduct the final inspection when the PRPs indicate they have completed all items on the punch list. Next, the Department and oversight officials re-inspect all punch list items requiring correction and verify that all re-conducted tests were completed satisfactorily. Finally, the PRPs and the Department generate a final punch list of any remaining items requiring correction or attention.

6.5.2 Project Closeout Report

At the completion of all punch list items, the PRP (usually the resident engineer) prepares a project closeout report which certifies that the PRP completed all items contained in the consent decree and any incorporated documents, (i.e. plans and specifications). The report includes documentation (e.g. test results) substantiating that the PRP met the performance standards and includes "as-built drawings" of the project. The Department or the oversight official reviews the project closeout report and verifies that all field changes and variations from the original drawings have been made on the as-built drawings.

6.5.3 Application for a Certification of Completion of Remedy

At remedy completion, the potentially responsible party, may submit to the Department, by registered mail, a request for certification of completion of remedy. The owner or operator or potentially responsible party must sign the application for certification of completion and include any necessary supporting documentation.

The supporting documentation must indicate that no hazardous materials and/or substances remain on site in any media above the cleanup levels established for the site. Any post-remedy analytical data should be of the same quality as that obtained during the remedial investigation, feasibility study and/or the remedial design and remedial action phase of the work.

Typically, the Department does not approve an application for certification of completion of remedy where hazardous materials and/or substances have been left on site (e.g., where institutional controls were implemented rather than remedial action to control hazards associated with the site).

References for Remedial Action

Guidance on EPA Oversight of Remedial Design and Remedial Actions Performed by Potentially Responsible Parties, Interim Final. EPA/540/G-90/001, OSWER Directive 9355.5-01, April 1990.

Superfund Remedial Design and Remedial Action Guidance. OSWER Directive 9355.0-4A, August 1986.

Quality in the Constructed Project: A Guide for Owners, Designers, and Contractors . Manuals and Reports of Engineering Practice No. 73, Volume 1. Salem Massachusetts: American Society of Civil Engineers, 1990.

Appendix A

Model Sampling and Analysis Plan (SAP)

ANYTOWN LANDFILL
SAMPLING AND ANALYSIS PLAN (SAP)

1. Project Name: Anytown Landfill RI/FS

2. Project Requested By: Delaware Department of Natural Resources and Environmental Control (DNREC)

3. Notice to Proceed: March 29, 1993

4. Project Officer: John Smith (DNREC Project Manager)

5. Quality Assurance Officer: John Doe (PRP Consultant)

6. Project Description:

A. Background

The Anytown Landfill site consists of approximately 272 acres, of which approximately 180 were available for landfilling. Anytown operated the landfill as a municipal solid waste disposal facility from 1966 to 1980.

Unknown quantities of waste oil, sludges, metal-plating wastes, lacquer and solvents are reported to have been illegally disposed of at several Delaware landfills, from 1974 through 1980, including the Anytown landfill. The exact quantities and disposal locations of the wastes were not known. It was reported that volumes of waste disposed of ranged from 11,000 to 55,000 gallons per week in 1984.

PRP Consultant's overall scope of work for the Anytown Landfill site includes an RI/FS, health risk assessment, and landfill closure design. The subjects of this Sampling and Analysis Plan (SAP) are the field sampling and data collection activities performed during the RI.

Objective And Scope

The overall objective of the RI is to define the nature, degree and extent of contamination at the Anytown Landfill, and to assess the risks to human health and to the environment. Specifically, the RI will seek to characterize contamination in the following media:

- groundwater
- subsurface soil/waste material
- surficial soil
- surface water and sediment
- ambient air
- landfill gas (including subsurface)

The results of the contaminant characterization will be used in the health risk assessment In addition to the contaminant characterization, neighboring critical habitats and wetlands will be identified to assess the landfill's impact on the ecosystem.

Groundwater

Limited groundwater quality data is available for the site. A total of 36 new monitoring wells will be installed and sampled to characterize the nature, degree, and extent of groundwater contamination. Also, two new piezometers will be installed. Well/piezometer boring data and water-level data will be used to define the site stratigraphy and hydraulic flow conditions.

Subsurface Soil/Waste Material

Subsurface soil and waste material within the landfill will be investigated through 23 borings and 20 test pits in order to identify contamination, delineate the extent of refuse filled areas, and to characterize the waste material for the purpose of cover design.

Surficial Soil

A total of 20 surface soil samples (10 on-site and 10 off-site) will be collected to characterize surficial soil contamination and to determine if the soils are impacting ambient air quality via particulates.

Surface Water and Sediment

Five surface water and five sediment samples will be collected from Allan Creek to characterize the nature, degree, and extent of contamination attributed to the landfill.

Ambient Air

Ambient air samples will be collected from 6 off-site locations to assess whether the landfill is significantly impacting ambient air through gaseous or particulate emissions. These air samples will also be used to assess the representativeness of the air dispersion model.

Landfill Gas

Landfill gas will be assessed in order to:

a) Determine the surface emission rate of toxic volatile organics into the air,

b) Determine whether landfill gas is migrating off-site through the subsurface.

To determine the surface emission rates, gas emission samples will be collected from 10 on-site locations using a flux box. The measured emission rates will be used as the landfill, area source term in the air dispersion model. The air model will be used to assess airborne health risk. Subsurface gas migration will be monitored from 18 permanent and 62 temporary gas monitoring probes.

C. Data Usage

The intended use of the data to be collected in the various field tasks is summarized below.

Data collected during the waste characterization includes soil/water analytical samples, geologic stratigraphy data, refuse thickness data, and refuse composition/ characterization. Surface and subsurface analytical samples will be used to characterize the nature, degree, and extent of contamination. In addition, surficial soils will be used to assess health risk. Data on refuse composition will be used to evaluate capping designs.

Data collected during the hydrogeologic characterization includes groundwater analytical samples and physical hydrogeologic data (e.g., stratigraphy, permeability, hydraulic conductivity, piezometric head). Groundwater analytical samples will be used to characterize the nature, degree, and extent of contamination, to assess human health risk and potential environmental impact on habitats/wetlands, to evaluate remedial alternatives, and to design a remedial system. Hydrogeologic data will be used to refine the conceptual model of contaminant transport, to evaluate remedial alternatives, and for use in remedial design.

Data collected in the leachate characterization includes only leachate analytical samples for the purpose of defining leachate chemical composition. Data collected during the air characterization includes surface emission analytical samples, ambient air analytical samples, and gas probe monitoring data. The surface emission samples will be used in the air model to assess human health risk, and will be used to evaluate cap requirements. The ambient air samples and gas probe monitoring data will be used to determine if landfill impacts are present.

Data collected during the surface water and sediment characterization includes analytical samples and tidal data. The analytical samples will be used to define the nature, degree, and extent of landfill attributed contamination, to assess human health risk, and to assess landfill impact on the wetlands ecosystem. The tidal data will be used in conjunction with hydrogeological data in order to characterize the groundwater flow field.

Data collected during the ecological investigation includes the identification of critical habitats, wetlands and areas of stress, and sediment toxicity data. This data will be used to assess the impact of landfill contamination on the ecosystem. In addition the presence of adjacent wetlands may be a factor in landfill closure design.

The land surface assessment includes only the collection of engineering quality data for use in the landfill cap design.

D. Monitoring Network Design And Rationale

The proposed sampling plan calls for the collection of environmental samples which can be broadly classified into the following categories:

Sample Type/Matrix	Number of Analytical Samples (incl. QA/QC samples)
Soil Boring/Test Pit Soil Samples	61
Surface Soil	24
Ground Water	94
Leachate	34
Air	
- gas emissions	49
- ambient air	30
- airborne particulate	36
Surface Water	13
Sediment	12

The monitoring parameters and frequency of sample collection for each QA/QC sample are summarized in Table A-1. The analytical methods, preservation are summarized in Table A-2 and container requirements are summarized in Table A-3. A brief explanation of the types of samples and purpose for collection is provided below:

1. Waste Characterization

An important objective of the RI/FS will be to characterize the nature and extent of landfill refuse within the site. Under the waste characterization task, a total of 20 test pits and 23 exploratory borings will be performed to achieve this objective. The test pits and borings will be advanced to the bottom of the fill material, but will not go through the marsh deposits underlying the fill. One analytical soil sample will be collected from each test pit/boring for a total of 43 environmental samples. The samples will be analyzed for TCL organics, TAL inorganics, releasable cyanides and sulfides, and geotechnical parameters (grain size distribution, particle size, hydrometer analysis, Atterberg limits, rated parameter, unit weight, permeability, and TOC).

Also under this task, shallow surface soil samples will be collected from 10 on-site and 10 off-site locations for laboratory analysis in order to determine the potential impact of fugitive dust from the site on ambient air. The shallow surface soil samples will be analyzed for TCL organics and TAL inorganics. This data will be compared against the ambient air particulate sampling data to see if there is an impact.

2. Hydrogeologic Characterization

Limited data is available on the site-specific geology, the groundwater flow conditions, and the nature/degree/extent of groundwater contamination. A hydrogeologic investigation will be performed that includes the installation of 36 new monitoring wells and 2 new piezometers. Approximately 8 of these will be from converted borings performed under the waste characterization.

Groundwater sampling will be performed in two rounds. The samples from the new monitoring wells and two existing monitoring wells will be analyzed for TCL organics, TAL inorganics, ion speciation, conventional parameters, and field parameters. Ion speciation consists of bromide, chloride, sulfate, carbonate, sodium, magnesium, and potassium. Conventional parameters consist of nitrate, nitrite, TKN, ammonia, BOD, COD, TDS, TOC, alkalinity, hardness, and turbidity. Field parameters consist of field measurements of pH, temperature, and specific conductance.

3. Leachate Characterization

Landfill leachate poses the greatest potential source of groundwater contamination for the Anytown Landfill. There is little available data on actual leachate quality for this site. To define the leachate quality, leachate samples will be collected from 10 locations, 5 monitoring wells screened in the landfill refuse and 5 leachate seeps, for laboratory analysis. Two rounds of samples will be collected. The samples will be analyzed for TCL organics (including a library search for 30 non-TCL organics), TAL inorganics, total petroleum hydrocarbons (TPH), ion speciation, conventional parameters, and field parameters.

4. Air Characterization

Air represents a major potential pathway for contaminant transport for landfills. An air characterization will be performed at the Brookfield site which will assess the following:

- The composition and the quantity of gaseous emissions from the landfill surface,
- The observed impact of landfill emissions on ambient air surrounding the site,
- The observed impact of respirable particulate emissions from the landfill on ambient air within and surrounding the site.

On-site gas emissions from the landfill surface will be quantified using flux boxes. The flux box will be placed over a representative location of the landfill surface, thereby isolating a portion of the surface from ambient wind conditions. A sweep gas will be passed through the flux box, and samples of the exit gas will be sampled to determine the composition and quantity of contaminants emitted through the isolated surface area. Flux box samples will be collected from 10 locations on-site during four sampling rounds. The locations will be established based upon a preliminary emissions survey using an OVA and a PID, and will be selected to cover a range of emission rates. The samples collected from the flux boxes will be analyzed for volatile organics (TO-14), methane, hydrogen sulfide, hydrogen cyanide, and mercaptans.

Ambient air samples will be collected from 6 off-site locations to assess the impact of the landfill on ambient air. Sampling locations will cover both upwind and downwind locations, and will be established based upon a thorough review of the historical wind patterns. The air samples will be collected over a 24-hr period, using continuous and wind activated sampling equipment, and will be analyzed for volatile organics (TO-14), methane, hydrogen sulfide, hydrogen cyanide, and mercaptans. Samples will be collected in four rounds. Air samples for suspended particulate as PM-10 will be collected from 2 on-site and 6 off-site locations to assess the potential impact of the landfill on ambient air due to particulate. PM-10 samples will be collected over an 8-hour period and will be analyzed for total PM-10 particulate and for particulate heavy metals. Samples will be collected in four rounds.

5. Soil Gas Characterization

In addition to surface emissions, landfill derived gases may migrate off-site through the subsurface. Subsurface gas concentrations will be monitored to assess whether significant concentrations of landfill gas is migrating off-site. Eighteen permanent soil gas probes, with two probes per nest, will be installed along the site perimeter outside the waste mass. Sixty-two temporary soil gas probes will be installed along the outside of the waste mass within the site. The permanent probes will be monitored once a month for one year using an OVA and a CGI to measure total hydrocarbon concentrations. The temporary probes will be monitored twice a month for five months.

6. Surface Water and Sediment Characterization

Past sampling data indicated that Allan Creek, located immediately north of the landfill, may have been impacted by landfill contamination. Surface water and sediment samples will be collected to assess if the landfill is currently impacting Allan Creek.

Five surface water samples will be collected from Allan Creek, along the landfill shore. Actual locations will be finalized based upon a preliminary field water quality survey. The preliminary survey win measure pH, temperature, and dissolved oxygen along the landfill shoreline to detect leachate plumes. Surface water sampling locations will be selected in those areas indicating the presence of a leachate plume. Surface water samples for laboratory analysis will be collected in one round with two samples per location, one each collected at mean low and mean high tides. The samples will be analyzed for TCL organics, TAL inorganics, TDS, and ion speciation.

Sediment samples will be collected from the same five surface water sampling locations. Sediment analytical samples will be collected using a Widco manual coring tool. A sample core will be collected from 0 to 24 inches into the creek bed. Two analytical samples will be collected from each sample core, one at 0 to 6 inches and one at 12 to 24 inches depth. The sediment samples will be analyzed for TCL organics, TAL inorganics, and geotechnical parameters.

7. Ecological Investigation

To evaluate the potential for ecological impacts, a natural resource inventory/wildlife habitat survey and sediment toxicity testing will be conducted at and in the vicinity of the site. The natural resource inventory/wildlife habitat survey will include a site reconnaissance and an inventory of stressed terrestrial and aquatic habitat. No samples will be collected during this activity.

Sediment samples will be collected from the five surface water sampling locations for use in toxicity testing. Approximately 15 gallons of sediment will be collected from each location using a Ponar dredge. In the toxicity testing, various organisms will be exposed to the sediment samples in order to measure acute and chronic toxicity effects. The testing procedure will be in accordance with the US Army Corps of Engineers testing method described in their dredging material disposal guidance document (1991). No analytical samples will be collected in this activity.

Quality Assurance

The following summaries describe the field sampling QA/QC requirements for the collection and analysis of soil, groundwater, surface water, sediment, and leachate samples.

- Duplicate samples - duplicate samples help to evaluate field and laboratory precision. Duplicate samples will be collected at a rate of 5% per matrix for this assignment or one duplicate for every 20 samples collected. If less than 20 samples are collected per matrix, one duplicate sample will be collected and analyzed.

- Trip blanks - trip blanks are used to determine if any on-site atmospheric contaminants are seeping into the sample vials or if any cross contamination of samples is occurring during shipment or storage of sample containers. Trip blanks are prepared prior to the sampling event in the actual sample containers and are kept with the investigative samples throughout the sampling event. They are handled and transported in the same manner as the samples collected that day and are then packaged for shipment with the other samples sent for analysis. At no time after their preparation are the sample containers opened before they reach the laboratory.

Trip blanks consist of two 40-ml Teflon lined septum vials that have been filled with distilled water. Trip blanks will accompany each sample shipment to be analyzed for volatile organics. Trip blanks are analyzed for volatile organics only. Trip blanks will not be used when non-aqueous samples are collected for volatile organics.

- Field blanks - field blanks are used to determine if the equipment decontamination procedures have been sufficient. A field blank consists of a group of laboratory-cleaned sample containers that are transported empty into the field. At the field location, distilled water is passed through the precleaned and/or decontaminated sampling equipment and placed into the empty group of containers for analysis. Field blanks are not collected when samples are collected directly into the sample container (i.e., the sample container is used as the collection device).

- Matrix Spike/Matrix Spike Duplicates - matrix spike/matrix spike duplicates are used to assess laboratory accuracy and precision. For the laboratory to perform a matrix spike/ matrix spike duplicate analysis, the laboratory must be supplied with triple the sample volume for aqueous extractibles (BNA/pesticides/PCBs) and one additional 40 ml VOA for aqueous volatile organics analysis. No additional sample volume is required for metal analysis for aqueous analysis or for all TCL/TAL parameters for non-aqueous samples. Matrix spike/matrix spike duplicates (MS/MSDs) are performed at the same frequency (1 to 20 samples) as duplicates.

The sample(s) to be utilized for matrix spike/matrix spike duplicate analysis will be collected from areas where contamination is suspected to be present. The sample label will note that the sample is to be used for matrix spike/matrix spike duplicate analysis by the laboratory.

The following are the QA/QC requirements for the collection of air samples:

- Duplicate samples - A minimum of one duplicate sample will be collected for each round of air sampling. Duplicate samples for ambient air sampling will consist of separate but identical sampling trains set-up at a designated location. Duplicate samples for gas emissions (flux box) sampling will consist of a single flux box with two identical sampling trains connected in parallel.

- Trip blanks - A minimum of one precleaned SUMMA canister, filled by the subcontracting laboratory with ultra-high purity, hydrocarbon free air (THC<0.05 ppm), will. be analyzed for each batch of canisters prepared and shipped to the site. Each blank will be kept in close proximity with the samples while they are being collected, as well as during transportation.

- Field blanks - Field blanks are not required for sampling using method TO-14.

- Matrix Spike/Matrix Spike Duplicate - Matrix spike/matrix spike duplicate analysis is not required for method TO-14.

E. Monitoring Parameters and Frequency of Collection for Each QA/QC Sample

See Table A-1.

F. Parameter Tables

See tables A-2 and A-3.

7. Project Fiscal Information:

Access to this information must be arranged through, and be by explicit consent of, responsible officials of DNREC and officers of Camp Dresser and McKee.

8. Schedule of Tasks and Projects

A schedule of activities is provided in Figure X-1.

9. Project Organization and Responsibility (Figure X-2)

	Project Manager
	RI Task Manager
	RI field Coordinator
(Contract Lab - to be determined)	Laboratory Analysis
(Responsibility of lab)	Laboratory QC
	Data Manager
	Regional QA Manager

10. Data Quality Requirements and Assessments:

The criteria of completeness is a measure of the amount of valid data obtained from the measurement system compared with the amount that was expected under normal conditions. This criteria is expressed as a percentage. Although a goal of 100 percent completeness is always desired, the EPA CLP data has been found to be 80 to 85 percent complete on a nationwide basis. A goal of 90 percent valid data has been set for the Anytown Landfill site. The acceptability of less than 90 percent valid data will be evaluated on a case-by-case basis.

Samples collected during the field investigations will be analyzed using the current DNREC Contract Laboratory Program (CLP).

The quality assurance requirements for accuracy, precision, and sensitivity of analysis will be the responsibility of the Contract Laboratory. All QA/QC requirements outlined in the DNREC Contract Laboratory Protocol will be adhered to.

11. Sampling Procedures:

Detailed procedures for the collection of samples are provided in the Attachment A, Standard Operating Procedures.

12. Sample Custody Procedures:

To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, a Chain-of-Custody (Figure A-3) will be completed for each sample cooler that is shipped to the laboratory. Each time the samples are transferred to another custodian, signatures of the person relinquishing the sample and receiving the sample, as well as the time and date, should document the transfer.

The team member performing the sampling is personally responsible for the care and custody of the samples collected until they are transferred or dispatched properly. In follow-up, the sampling team leader reviews all field activities to confirm that proper custody procedures were followed during the field work

The top original signature of the Chain-of-Custody is enclosed in plastic and secured to the inside of the cooler lid. A copy of the custody record is retained for the Project Team's files.

13. Calibration Procedures and Preventive Maintenance:

Each piece of equipment used in activities affecting quality is calibrated and maintained periodically to assure accuracy within specified limits. At a minimum, calibration and maintenance procedures conform with the manufacturer's specifications. The manufacturer's specifications for each piece of equipment are available to Project Team personnel upon request.

All equipment used in analysis or sampling has a documented maintenance and/or calibration procedure. These procedures are available to all personnel.

Calibration procedures and frequency of calibration for field equipment is an integral component of each instrument's Standard Operating Procedure. The relevant procedures are enclosed in Attachment A.

The laboratory is responsible for maintaining calibration and maintenance schedules for each piece of laboratory equipment. These requirements are detailed in the DNREC Contract Laboratory Protocol Manual.

14. Documentation, Data Reduction and Reporting

A. Documentation: Each sample submitted for analysis will be properly documented to ensure timely, correct and complete analysis for all parameters requested, and to support use of analytical data in potential enforcement actions. Sample documentation will include sample labels, Contract Lab Sample Information Sheets, and Chain-of-Custody Records.

Field data will be entered into a bound notebook. Each page shall be initialed, signed, and dated by the individual responsible for record keeping. All relevant data which includes sample code, location, names of sampling personnel, and date will also be provided in a separate sampling trip report. This report will be transmitted to DNREC.

B. Data Reduction and Reporting: A hardcopy of the organic and inorganic data submitted by the lab will be accompanied by a 5-1/4 inch floppy diskette, which may be either a double-sided, double density, 360 K-byte or a high capacity 1.2 M-byte diskette. The diskette must be formatted (format A) and recorded using the MS-DOS Operating System. The diskette or diskettes must contain all information relevant on one, and only one, Sample Delivery Group, and must accompany the hardcopy package for the Sample Delivery Group submitted to the Project Team.

The diskettes containing the analytical data from the Contract laboratory will be loaded directly into the PRP Consultant's data management program.

Routines available on data management program create thematic maps important for site analysis that display data in a spatial format. The thematic mapping routines operate using named plots. The types of plots available include:

- Posting for well locations, well stratigraphy, water level data and water and soil and soil gas quality data.

- Contour plots for well stratigraphy, water level data and water quality data.

- Fence (profile) diagrams for well stratigraphy.

All physical and chemical data will be presented in the Remedial Investigation/Feasibility Study reports in both tabular and graphical formats

15. Data Validation:

The Contract laboratory is required to submit the data package within 30 days of sample receipt.

Organic analytical data from the analysis for the volatile, semi-volatile and pesticide/PCB Target Compound List (TCL) will be reviewed by a data validation subcontractor based upon analytical and quality assurance requirements specified in the EPA CLP Statement of Work (SOW) 2/88 and 9/88 revisions, using the EPA Region III Standard Operating Procedure (SOP) for data validation. The GC/MS mass spectra of Tentatively Identified Compounds (TICS) will be reviewed using EPA CLP guidelines and best professional judgement.

Inorganic analytical data from the analysis of samples for the Target Analyte List (TAL) will be reviewed based upon analytical and quality assurance requirements specified in the EPA CLP

Statement of Work (SOW) 7/88 and 2/89 revisions, using the EPA Region III Standard Operating Procedure (SOP) for data validation. Based upon the intended use of the data, the following analytical data will require validation:

Soil boring samples
Shallow surface soil samples
Groundwater monitoring well samples
Leachate seep and leachate monitoring well samples
Surface water samples
Sediment samples
On-site gas emissions samples
Off-site ambient air samples

Analytical data will be reviewed to determine the usability of results and to determine contractual compliance relative to the deliverable and quality control requirements of the EPA CLP and Region III. The Data Validation Reports will generally follow the Region III format to include: a tabular Summary of Data Qualifications; a Data Assessment Narrative, divided into general comments and specific findings for each analytical fraction; and the qualified Form I's for the data reviewed which will be annotated with Region III Data Validation Footnotes or referenced to the numerical listing of specific findings from the narrative describing the conditions and causes for qualification or rejection of individual analyses.

The Data Validation Report will also include the completed checklist portion of the appropriate Region III SOP, the completed Regional Data Assessment Summary, all records of conversation documenting questions and requests by the validation subcontractors to the analytical laboratory and finally, any resubmissions or additional information supplied by the laboratory in support of the data review and validation. In addition, a data usability report will be prepared by the QAO summarizing the results of data validation and whether or not the samples were found to be in compliance with the ASP QA/QC requirements. The useability report will include the justification for the use of any non-compliant data and the identification of any data gaps as a result of rejected data. The field measurements of pH and specific conductivity will be considered acceptable for use if the calibration procedures as specified in this FOP were correctly followed and used by the field staff and if the duplicate analyses met the precision requirement of +/- 25 percent.

Data processing QC will be assessed by the designated team member. This task will consist of checking data entry accuracy against the laboratory data packages and the field notebooks.

16. Performance and Systems Audits:

Performance audits are quantitative checks on various aspects of project activities and are most appropriate to field measurements and analysis activities. Performance audit techniques include checks on field equipment measurements and the evaluation of laboratory performance with performance evaluation (PE) samples. Except for simple field measurements of pH, specific conductivity, and dissolved oxygen, analytical field measurements will not be performed for this assignment. In addition, the calibration and maintenance of these instruments should provide usable data. Therefore, no performance audits of these simple field measurements will be performed.

The selected laboratory for the analysis of the environmental samples will be a DNREC CLP laboratory. The analytical laboratory shall maintain DNREC certification throughout the performance of the work Therefore, a performance audit of the CLP laboratory win not be conducted by CDM.

A technical systems audit or field audit is used to verify that a system of quality control measures, procedures, reviews and approvals were established and used as specified in this SAP (e.g., procedures for preserving, shipping, documenting, and analyzing the samples) and/or the Health and Safety Plan. A technical systems audit will not be conducted for this phase of the work because the length of time in the field is relatively short. En addition, an on-site monitor reporting to DNREC will be present to observe the sampling activities performed during this field event.

An internal systems audit is used to check for the use of QC measures and typically includes: interviewing the Site Manager and project personnel; determining if deliverables identified in the work plan have been prepared; determining if documents received proper technical and/or QA review; reviewing files for appropriate memos, QC records, or other documentation; and examining the central files to evaluate filing and storage of deliverables. An internal systems audit will be conducted by Curt Velsor, Lee Guterman, or their designee at the completion of the project in accordance with the procedures outlined in the QA Management Plan.

17. Corrective Action:

The corrective action program operates to prevent problems, but also serves to identify and correct those that may exist. Usually these problems require on-the-spot, immediate corrective action.

Predetermined limits for data acceptability have been established for the field measurements and the analytical work. Corrective action for field work will be initiated whenever these QC limits (e.g., calibration acceptance criteria are not met) for a particular field. It is the Project Manager's responsibility for ensuring that no additional work, which is dependent on the nonconforming activity, is performed until the nonconformance is corrected.

Corrective actions for the analytical work are specified in the CLP Statements of Work. The subcontracted laboratory will be required to follow these corrective actions.

The project team will be responsible for reporting all suspected technical nonconformances. Any staff member who discovers or suspects a nonconformance, which is an identified or suspected deficiency in an approved document, is responsible for informing the QA and Project Managers. The Project Manager is responsible for instituting and completing the corrective action. The QA Manager is responsible for ensuring that the Project Manager takes the appropriate steps for responding to a nonconformance issue.

If a nonconformance or deficiency is identified during the work assignment or during the internal systems audit, corrective action will be initiated by the project team. The corrective action steps are:

- Identify and define the problem
- Assign responsibility for investigating the problem
- Determine corrective action to eliminate the problem
- Assign and accept responsibility for implementation of the corrective action
- Implement the corrective action
- Verify that the corrective action has eliminated the problem
- Document the identified problem, the corrective action taken, and its effectiveness in eliminating the problem

18. Reports:

An RI Report will be prepared for DNREC incorporating all pertinent field and laboratory data collected during the RI investigation. This report will include the following:

- Objectives of the RI;
- Site descriptions, including the environmental setting of the site;
- Maps and cross sections of the site stratigraphy;
- Hydrogeologic conditions;
- Nature and extent of groundwater contamination;
- Identification of other potential sources of contamination;
- Supporting data such as well logs, laboratory results, etc.;
- Contaminant pathway and transport evaluation;
- Risk assessment; and
- Conclusions and recommendations for any Phase II RI activities or immediate response actions required.

APPENDIX B

SUGGESTED RI REPORT FORMAT

Executive Summary

1 Introduction
- 1.1 Purpose of Report
- 1.2 Facility Background
  - 1.2.1 Facility Description
  - 1.2.2 Facility History
  - 1.2.3 Previous Investigations
- 1.3 Report Organization

2 Site Physical Characteristics
- 2.1 Operational History
- 2.2 Geology
- 2.3 Hydrogeology
- 2.4 Surface Water Hydrology
- 2.5 Meteorology
- 2.6 Demography and Land Use
- 2.7 Ecology

3 Nature and Extent of Contamination
- 3.1 Sources
- 3.2 Soils
- 3.3 Groundwater
- 3.4 Surface Water
- 3.5 Sediments
- 3.6 Air
- 3.7 Biota

4 Contaminant Fate and Transport
- 4.1 Potential Routes of Migration
- 4.2 Contaminant Persistence
- 4.3 Contaminant Migration
  - 4.3.1 Factors Affecting Contaminant Migration
  - 4.3.2 Modeling Methods and Results

APPENDIX B

SUGGESTED RI REPORT FORMAT

(Continued)

5 Baseline Risk Assessment
- 5.1 Public Health Evaluation
  - 5.1.1 Data Evaluation
  - 5.1.2 Exposure Assessment
  - 5.1.3 Toxicity Assessment
  - 5.1.4 Risk Characterization
  - 5.1.5 Uncertainty Evaluation
- 5.2 Ecological Assessment
  - 5.2.1 Ecological Characterization
  - 5.2.2 Identification of Chemicals of Concern
  - 5.2.3 Exposure Assessment
  - 5.2.4 Ecological Effects Assessment
  - 5.2.5 Ecological Risk Characterization
  - 5.2.6 Uncertainty Evaluation

6 Summary and Conclusions
- 6.1 Summary
  - 6.1.1 Nature and Extent of Contamination
  - 6.1.2 Fate and Transport
  - 6.1.3 Risk Assessment
- 6.2 Conclusions
  - 6.2.1 Date Limitations and Recommendations for Future Work

APPENDIX C

SUGGESTED FS REPORT FORMAT

Executive Summary

1 Introduction
- 1.1 Purpose and Organization of Report
- 1.2 Background Information (Summarized from the RI report)
  - 1.2.1 Site Description
  - 1.2.2 Site History
  - 1.2.3 Nature and Extent of Contamination
  - 1.2.4 Contaminant Fate and Transport
  - 1.2.5 Baseline Risk Assessment
  - 1.2.6 Applicable Local, State and Federal Requirements
- 1.3 Remedial Action Objectives
  - 1.3.1 Qualitative
  - 1.3.2 Quantitative
- 1.4 Volumes of Contaminated Media

2 Development of Remedial Action Alternatives
- 2.1 Introduction
- 2.2 Identification of General Response Actions
- 2.3 Identification and Screening of Technology Types
- 2.4 Identification and Screening of Process Options
- 2.5 Development of Alternatives

3 Screening of Alternatives
- 3.1 Introduction

(For each alternative to be evaluated):
- 3.2 Alternative 1
  - 3.2.1 Description
  - 3.2.2 Evaluation
- 3.3 Selection of Alternatives for Detailed Analysis

4 Detailed Analysis of Alternatives
- 4.1 Introduction
- 4.2 Individual Analysis of Alternatives

(For each alternative to be evaluated):
  - 4.2.1 Description
  - 4.2.2 Protection of public health, welfare, and the environment
  - 4.2.3 Compliance with applicable laws and regulations

APPENDIX C

SUGGESTED FS REPORT FORMAT

(Continued)

4.2.4 Community acceptance
4.2.5 Compliance monitoring requirements
4.2.6 Permanence
4.2.7 Technical practicability
4.2.8 Restoration time frame
4.2.9 Reduction of toxicity, mobility and volume of contamination
4.2.10 Long-term effectiveness
4.2.11 Short-term effectiveness

4.3 Comparative Analysis of Alternatives (optional as discussed on page 5-8)
4.3.1 Protection of public health or welfare or the environment
4.3.2 Compliance with applicable laws and regulations
4.3.3 Community acceptance
4.3.4 Compliance monitoring requirements
4.3.5 Permanence
4.3.6 Technical practicability
4.3.7 Restoration time frame
4.3.8 Reduction of toxicity, mobility and volume of contamination
4.3.9 Long-term effectiveness
4.3.10 Short-term effectiveness

4.4 Preferred Alternative and Justification

Bibliography
Appendices

APPENDIX D

SUGGESTED REMEDIAL DESIGN REPORT FORMAT

Executive Summary

1 Introduction

2 Site Description

3 Site History and Enforcement Activities
- 3.1 Field Studies
- 3.2 Laboratory Studies (bench scale, pilot studies)

4 Remedial Action Scope of Work

5 Design Requirements and Provisions
- 5.1 Special Technical Problems
- 5.2 Additional Engineering Data Requirements
- 5.3 Permit and Regulatory Requirements
- 5.4 Access, Easements, Right-of-ways
- 5.5 Community Relations Activities

6 Deed Restrictions

7 Construction Activities

8 Erosion and Sediment Control

9 Other Plans
- 9.1 Sampling and Analysis Plan
- 9.2 Construction Quality Assurance Plan
- 9.3 Health and Safety Plan
- 9.4 Decontamination Plan
- 9.5 Operation and Maintenance Plan
- 9.6 Contingency Plan
- 9.7 Remedial Action Work Plan
- 9.8 Cost Estimate and Schedules
  - 9.8.1 Implementation Cost Estimate (order of magnitude, +50%/-30%)
  - 9.8.2 Preliminary Annual O&M Cost Estimate and Duration
  - 9.8.3 Project Schedule (design, construction, permits & access)
- 9.9 Field Manual

Appendices
- Reports
- Data Summaries

APPENDIX E

BASIC ELEMENTS OF OPERATION AND MAINTENANCE PLAN

1 Description of Normal Operation and Maintenance
- 1.1 Description of tasks for operation
- 1.2 Description of tasks for maintenance
- 1.3 Description of prescribed treatment or operating conditions
- 1.4 Schedule showing frequency of each O&M task

2 Description of Potential Operating Problems
- 2.1 Description of analysis of potential operating problems
- 2.2 Sources of information regarding problems
- 2.3 Common remedies

3 Description of Routine Monitoring and Laboratory Testing
- 3.1 Description of monitoring tasks
- 3.2 Description of required laboratory tests and their interpretation
- 3.3 Required QA/QC
- 3.4 Schedule of monitoring frequency and when, if so provided, to discontinue

4 Description of Alternate O&M
- 4.1 Should systems fail, alternate procedures to prevent undue hazard
- 4.2 Analysis of vulnerability and additional resource requirements should a failure occur

5 Health And Safety Plan (HASP)
- 5.1 Description of precautions, of necessary equipment, etc., for site personnel
- 5.2 Safety tasks required in event of systems failure, (May be linked to site safety plan developed during remedial response)

6 Description of Equipment
- 6.1 Equipment necessary to plan
- 6.2 Installation of monitoring components
- 6.3 Maintenance of site equipment
- 6.4 Replacement schedule for equipment and installed components

7 O&M Annual Budget
- 7.1 Cost of personnel
- 7.2 Costs of preventative and corrective maintenance
- 7.3 Costs of equipment, supplies, etc.
- 7.4 Costs of any contractual obligation (e.g. lab expenses, etc.)
- 7.5 Costs of operation (e.g. energy cost, etc.)

APPENDIX E

BASIC ELEMENTS OF OPERATION AND MAINTENANCE PLAN

(Continued)

8 Records and Reporting Mechanisms Required
- 8.1 Daily Operating Logs
- 8.2 Laboratory Records
- 8.3 Records for Operating Costs
- 8.4 Mechanisms for reporting emergencies
- 8.5 Personnel and maintenance records
- 8.6 Monthly/Annual Reports to State Agencies